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AND RESOURCE GUIDE FOR

NEW EDITION

You and Science

SCIENCE FOR BETTER LIVING

WITH ANSWER KEY TO Harbrace Teaching Tests

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Contents

To the Teacher of General Science

> General science is a course of scientific study and investigation which has its roots in the common experience of children and which does not exclude any one of the fundamental special sciences. It seeks to elucidate the general principles observable in nature, without emphasizing the traditional division into specialized subjects until such time as this is warranted by the increasing complexity of the field of investigation, by the developing unity of separate parts of that field, and by the intellectual progress of the pupils.

Thus does the British Science Master's Association characterize the nature of general science in its report.* It is a good statement.

General science is, in a sense, the oldest of the sciences. Aristotle was a "general scientist"; so was Galileo. One could hardly call either of them a chemist, a biologist, or a physicist. General science is perhaps an unfortunate term; the adjective hardly indicates the purpose of the course. We do not say general physics, general chemistry, or general biology; we should, because these are very general treatments of the areas concerned, but we don't.

General science at the junior high school level (usually required courses in two or three years) is perhaps the most important group of courses in the science curriculum. It is there that the student has an opportunity to see science as a way of life: interesting, exciting, full of possibilities for personal accomplishment, fun, adventure, hard work, and high purpose. To hear science teachers reflect on the low enrollments in physics or chemistry is saddening; perhaps they fail to realize that the student's election of advanced courses is based upon his prior experience in the subject area. Experience in the various subject areas is given in general science; indeed it is one of the main purposes of introducing the course.

Further, it goes without saying that children do not have experiences in only one area; modern life furnishes stimuli in all areas. Science is no different. General science, which is not meant to exclude experience in *any* of the fundamental sciences, feeds the curiosity and interests of the children whose experiences are fresh ones, day in, day out.

The *Science for Better Living* Program, in its totality, is in line with these reflections; it does not exclude experiences in any of the fundamental sciences. Furthermore it is built to meet the needs of teachers whose courses are organized according to any of the

*Science Master's Association, *The Teaching of General Science,* John Murray, London, 1952, p. 30.

approaches outlined on pages 6-9 of this Manual. The science texts in this program have been based on careful study of various curriculums throughout the country and of practices of many teachers as revealed by both observation and consultation.

The *Science for Better Living* Program has been built on a major principle of man's effort to deal with certain of his problems: Man has attempted to overcome biological and physical obstacles by the use of biological and physical principles; he has built for himself a map of the biological and physical universe and of the way it works; he has invented a way—a method of intelligence, if you will—which helps him to investigate and understand the discoverable regularities of nature.

Also built into the *Science for Better Living* Program is the impact of science on life and living. Because of this ever-increasing impact, every youngster must understand the ways of the scientist and the effects of science on his life. In view of the grave need in our country for scientists and for citizens who understand the scientist, the *science teacher* has become a major resource. If science is indeed to be used for better living, the science teacher remains a key person—*the* key person.

The purpose of this Manual is to give suggestions and information for both experienced teachers and those who are in the early years of their teaching career. Inasmuch as today there are many approaches to teaching science, we hope that some of the ideas in this Manual will prove of value in enriching the teaching of general science with *You and Science* as the text. Teaching is truly a personal invention and each teacher elaborates his own methods, techniques, and procedures. This Manual is meant to encourage personal invention through suggestions supplementing teaching procedures.

PART **A**

APPROACHES TO TEACHING GENERAL SCIENCE

PART A
Approaches to Teaching General Science

CHAPTER 1: PATTERNS IN COURSES OF STUDY

There are several approaches to the organization of the science curriculum. The variations stem from a basic concept relating to the teaching of general science. In its nature and in its tradition general science is exploratory; hence its role in the curricular structure is fluid and permissive. It permits pupils to explore themselves and their environment, and it permits teachers to explore the capacities of their pupils and to encourage developing interests. It does not envisage termination of education in science, but generally diversification and specialization—at the secondary level, of course—in biology, physics, and chemistry.

General science builds on the elementary school and, depending on the grade, one or more years of junior high school. The preparation of students is not uniform at the present time; and it will probably not be for the next decade. Some students have had a great deal of science; others only one or two years. In junior high school, then, we are concerned with pulling together and expanding their concepts about science—in one, two, or three years.

In line with the conception that the junior high school program permits students to explore their interests in order to determine their avenues of competence, the general science course, through one or more years, explores not only the ways of the scientist but also the ways of the youngster. He is in the adolescent years, beginning to explore himself and his environment with curiosity and in an organized way—he builds on his past experience; he is on his way to becoming a serious collector or a serious moonwatcher, by way of example.

It is sometimes proposed that children begin the discipline of specialization as soon as they can, say in junior high school. Why not "expose the kids" to biology, chemistry, or physics as early as ninth grade?

In the period from 1947-50, at Forest Hills High School in New York City, the experiment was tried of substituting earth science in the usual four-year sequence (———, biology, chemistry, physics). Two classes of superior students were selected, each class with an equivalent range in I.Q., reading, and mathematics. One class (thirty-five students) had the following sequence: earth science, biology, chemistry, physics. The control group had general science instead of earth science. In successive years (ending in

1953) it was planned to substitute biology, chemistry, and physics for general science. After the third year, before physics was substituted for general science, the "experiment" had to be abandoned, for these reasons.

First, the basic assumption that the children's preparation in science was uniform was found to be incorrect. Some students had had a great deal of science, others very little. Some had had "nature study" science, others "sporadic" science. This would ordinarily not have been critical were it not for the factors that accompany the onset of adolescence. Puberty is a difficult period. Picture the anxieties of children, whose abilities give them the capacity to succeed, and who are eager to succeed in high school, faced with a course that assumes uniform experience in science. Also, the course itself (say, chemistry—or even biology) assumes some kind of discipline in study, an ability to take laboratory work in stride, and a bit of familiarity with mathematics.

After the third year of this "experiment," it was found that about 35% of those who had had earth science, 40% of those who had had biology, and 30% of those who had had chemistry in the ninth grade indicated any intention of taking three more years of science; while 85% of the "controls," those who had had general science, expressed the intention of continuing with three more years of science.

An analysis of the situation revealed other considerations:

1. The children given an exploratory course in general science in the ninth grade or continuing a sequence of general science begun in junior high school benefit from its *guidance function.* They use it to plan further experiences along their interests. Thus general science, if it is a broadly conceived course touching differing areas of life, opens many vistas in further course work as well as in vocations.

2. Since adolescence is a period of stress and strain,* it is healthy to give youngsters a good base consisting in a "new view," not review, of the concepts they "should have studied"; and, at the same time, to point their energies in a new direction.

3. The maturity of students makes a difference. Students in tenth, eleventh, and twelfth grades achieve higher grades than do their younger counterparts of equivalent I.Q., reading, and mathematics test scores who take the same course in the ninth grade. When biology and chemistry were offered in the ninth grade, seven out of ten of these able pupils scored below 80% on the achievement scale. Of the comparable students who took biology in the tenth grade and chemistry in the eleventh grade, following a general

*See, for example, A. W. Blair and W. H. Burton, *Growth and Development of the Preadolescent,* Appleton, 1951. A. J. Jersild, *The Psychology of Adolescence,* Macmillan, 1957.

science course in the ninth grade, seven out of ten achieved scores above 90%.*

This lower achievement in biology was somewhat surprising, although the lower achievement in chemistry had been suspected as likely. Among the many factors that might account for this lower achievement in biology were the high vocabulary load of new words and the involvement of mature abstractions such as evolution and chromosome theory. Goldstein,† writing in *The Science Teacher*, comes to similar conclusions.

An interesting conclusion, still tentative, of course, is that if biology, chemistry, physics, or earth science were to be given in ninth grade, they would have to be given at the level of general science.

VARIATIONS IN TIME ALLOTMENT

The time given over to exploration of science in the junior high school grades varies in different school systems. Naturally, the expectation is that students will extend their work at home. There are also variations, in scheduling the time for general science, based on the type of school organization.

a. In many 8-4 schools and 6-3-3 schools, science is taught in all three years, i.e., grades seven, eight, and nine. Some schools may have 5 periods per week in the first semester of grade seven, and no science in the second semester. In grade eight, science may be an optional subject (5 periods per week for one semester). Grade nine meets 5 times a week for the year.

b. In other 8-4 and 6-3-3 schools general science is completed in grade eight. A few schools have attempted to complete general science on a 5-periods-per-week basis in grades seven and eight, replacing ninth-year science with a year of biology, physical science, or earth science.

c. In still other 8-4 and 6-3-3 schools science is completed in grade nine after limited coverage in grades seven and eight. Two periods per week in the first or second semester of grades seven and eight have been tried in some schools. The amount of time allotted in grades seven and eight appears generally to be increasing.

d. In 6-2-4 schools variable patterns may also exist. For instance, science may be given 2 periods a week for the entire year in grade seven, or 5 periods in one semester; similarly there may be 2 periods a week in grade eight for the entire year, or 5 periods in one semester. Or there may be more time than this allotted. Science may also be optional in either grade seven or grade eight.

*Earth science was not offered in grades 10, 11, or 12.

†Goldstein, P., "Concerning Ninth-Year Biology," *The Science Teacher*, Vol. 25, No. 8, Dec., 1958, pp. 454-57.

The greatest variables exist in grades 1 to 6 in most schools. Some systems start with a strong science program at the kindergarten level; others do not start until later.

In summary, a study of the periods allotted to general science in the junior high school years over the country shows the following variations:

Periods Allotted	Seventh Grade	Eighth Grade	Ninth Grade
Plan A	2	3	5
Plan B	3	3	5
Plan C	3	4	5
Plan D	2	4	4
Plan E	0	2	5
Plan F	0	0	5

VARIATIONS IN APPROACH

It is clear from the above that no one plan or organization is practiced country-wide, nor is one practicable. There are many approaches to the general science program:

1. An Approach Based on an Elementary Science Program. Elementary science programs are growing steadily throughout the country. Where an elementary science program exists, teachers generally build upon it. Sometimes the teacher can build on acquired knowledge and leave more time for work in other topics. For instance, the topics of astronomy, natural history of plants and animals, nutrition, simple body structure, and simple elements of weather may have been dealt with effectively in the elementary school.

The National Defense Act of 1958* with its provisions for aid to schools in the purchase of science equipment and improvement of science-teaching facilities is further direct proof that the elementary science program is on its way to becoming more effective, and it will be felt in the general science program for grades seven and eight, and especially nine.

Therefore, in building the course of study within the curricular pattern for your school, you will want to base its structure upon the foundation of the science training given in the elementary school.

*National Defense Education Act of 1958, Public Law 864 of the 85th Congress. Title III, Part A, provides for certain kinds of financial assistance to public and private *elementary* and secondary schools including junior colleges for strengthening science, mathematics, and modern language instruction through purchase of equipment and minor remodeling of classrooms and laboratories.

2. An Approach Based on a "Contract Plan." It is interesting to see how many schools use this plan, although the word "contract" may be replaced with the terms "reports," "honor readings," "special assignments," "special credit," and other terms. The essence of this plan is:

a. The teacher knows that it is not possible, or desirable, to teach all the science in the course of study in the time allotted—or he does not wish to do so. Often, he believes, on the basis of the success of the contract plan as practiced in various schools, it has a place in his own school program.

b. He therefore "assigns" certain topics to be studied by pupils primarily on their own. These topics (or aspects of them) are essentially those the student may read about or do "experiments" in because reading material and experimental material in addition to text material are readily available; e.g., diet, conservation, plants and animals. The students will have an opportunity to ask questions on these topics, but formal classroom time and treatment are not given. Learning on these topics is usually tested.

c. In carrying out the plan, the teacher may make available a mimeographed "study outline"—a sheet on which questions dealing with the topic are placed in sequence. Reference is made to pages in the text and to reference books in the library. As has been indicated, some "contracts" also have activities which the pupil may do at home. In a sense the assignment becomes a "contract" when the student promises to "fulfill" the work by a certain date and signs a "promissory note" to that effect.

For instance, the teacher may feel that his time allotment is such that he cannot spend as many classroom periods as he would like on astronomy or conservation or nutrition or airplanes or the structure and function of eyes and ears. Also, he feels that students already know a good deal about these topics. Hence he assigns them in contract form. He may expect a full report, or a notebook showing the "notes" on these topics; or he may content himself with a quiz in written or oral form.

3. An Approach Based on "Planning" with Students. In some parts of the country, pupils and teachers plan the term's or year's work together. That is, the teacher asks, "What important things can we learn in science this year?" The students suggest topics and vote on them; the teacher guides the discussion, but he does not abdicate. He sees to it that topics are chosen on the following grounds, keeping these questions constantly before the class:

Why is this topic important?

How will it help you live a better life?

Which topics shall we study in the short amount of class time we have?

The choice of topics may be restricted to a general term's

topic. It may be based on a text. For example, *You and Science* is planned as a complete course which permits a wide choice of topics in a one-year science course.

In any event, planning with pupils permits selection of topics within the time allotted and thus permits emphasis on the topics selected.

4. **An Approach to a Three-Year Course of Study.** The approaches cited above apply to selection of material and its presentation in a single year of work within whatever curricular sequence may exist in your school system. Most curriculums in general science are organized over three years—occasionally over two. The approaches in each year may be based on the pupils' training in elementary science, on a "contract" plan, on pupil-teacher planning, or on combinations of these. Most curriculums in general science have a definite plan for organizing the work over the entire period. Two major plans are described below.

The "Block and Gap" Organization. Essentially this organization is based on the assumption that a full, complete, and terminal course in science cannot be given in each year. In part, this is the result of having fewer than four or five periods a week in the first two years of junior high school science. In part, it is also due to the belief that certain concepts can be explored more fully in certain years of the curriculum because of the background or level of maturity of the pupils. Most schools using the "block and gap" organization of the curriculum permit wide discretion in its fulfillment.

In a three-year course of study, the third year usually has five periods of class study per week. Essentially, then, the third year fills in the *gaps* in the preceding years and builds on the *blocks*.

The Spiral Organization. This organization assumes that content and concepts are best taught if some aspect of each major area in science is taught each year. Subject matter is therefore repeated, but in different context. Each concept is broadened and deepened each year.

In such a curricular organization, the course of study for each year will include some aspect of human biology, some aspect of man's environment, some aspect of man's use of energy, etc. For instance, under this plan, the first year of junior high school science may include a study of the body and its functions together with disease and its prevention; the second year may deal with the foods needed for proper body growth and repair; the third year may build on these by a deeper treatment of bodily growth in relation to diet, disease prevention, and community practices.

The teacher, by building on what has gone before (including the elementary years), by selecting additional content by one of the methods available (contract plan, student-teacher planning, and

others), goes on adding to the concept. But most important, he uses the general science course to guide the student toward his avenue of competence. He does this through a course he makes rich in science experiences—demonstrations, readings, laboratory work, field trips, films and filmstrips, individual and group projects, and so on. He uses all the skills of the master teacher.

THE *SCIENCE FOR BETTER LIVING* PROGRAM

The *Science for Better Living* Program is developed in recognition of the variable time allotments to general science in junior high school grades and recognizes there are merits in presenting a course flexible enough to be adapted to either the "block and gap" or the spiral organization. Essentially, *You and Your World*, new edition, the first book in the series, stresses discovery. Thus, the pupil first is introduced to the work and discoveries of scientists; this work has led to a better understanding of the causes of disease which threaten each person's well-being and of possible cures which enable each person to realize his fuller potentialities. The pupil then goes on to discover more about himself and his immediate and visible environment. By the end of the year, he will have discovered ways in which the scientist works.

You and Your Resources, the second book in the series, builds on understandings developed in the first book, presenting them in new contexts, and it introduces new avenues of exploration such as common chemicals and resources in the earth. In exploring resources, the pupil is led to an understanding of the structure of matter and of some of the forms of energy that have been tamed for better living. As discovery is the general theme of the first book, investigation of careers in the areas of pure and applied sciences is encouraged in the second text.

You and Science, new edition, the third book in the series, extends the concepts developed in the first two books and gives the pupil a deeper understanding of the principles of science that affect him and that he uses, either directly or in evaluating experiences. Thus, although each book stresses certain different areas of science, any concept or principle in science once introduced is utilized repeatedly and in various contexts.

Where the science curriculum in the junior high school—whether it be organized in a 6-3-3, an 8-4, a 6-2-4, or a 6-6 system—calls for a two-year sequence followed by a subject-oriented course such as biology, earth science, or physical science, it is entirely possible to use any two books in the *Science for Better Living* Program, depending on the content or concepts desired for the first two years. It is not our intention to suggest a curriculum in general science; that is the province of each school system. But we do suggest that the *Science for Better Living* Program provides

a flexible course of study which can be adapted for most curriculums we know about. For fuller coverage of the concepts and teaching resources for each book, we encourage examination of the separate Teacher's Manuals for *You and Your World, You and Your Resources,* and *You and Science.*

CHAPTER 2: GENERAL APPROACHES TO *YOU AND SCIENCE*

A textbook is an important tool that permits the widest latitude in teaching approach. *You and Science*, together with this Manual, make available a variety of activities for an enriched course in science. Both suggest such teaching techniques as experimental work in and outside the classroom, library reading, field trips, films, and demonstrations that allow for pupil analysis. These techniques are equivalent to investigative procedures that lead to concept formation. Let us look at some of the techniques made available in the content and organization of *You and Science.*

INVESTIGATIVE EXPERIENCES AND ACTIVITIES

Pupils who are encouraged to perform "experiments" and demonstrations solely to verify an idea or concept carefully spelled out in advance are denied the thrill of discovery; they merely go through a sequence of events they know, in which stress is placed on the technology or on the mechanical steps in the procedure of verification. Of course, there is learning value in verification; but if an atmosphere of planning and analysis can be encouraged, the pupil's "discovery" resulting from natural or stimulated curiosity results in more thorough learning as well as the development of useful concepts. The investigative experiences and activities in *You and Science* are of several kinds.

1. Experiences of Discovery in School. Experiments and activities are built into the text and usually set off in heavier type. (For a complete listing of built-in experiments and activities, see text page 697.) As a result teachers can use the text as a combined text-workbook; that is, pupils read the text pages and are introduced to an experiment or another type of activity which they can then do in class. The activity on page 87 calls for a simple observation of vein distribution in the student's arm. Although it is not developed in the text, some students will note temporarily bulging sections along the veins, which indicate the presence of valves. The alert teacher can quickly turn what seemed to be a

routine observation into library research or other activities. Curiosity will lead along concept-seeking lines toward eventual formation of a series of related elements or facts arising from additional observations.

2. **Experiences of Discovery at Home.** Many of the activities written into the text may be done at home. Such activities as those on text page 484 (making a magnet from a steel darning needle) and 493 (reading and observing an electric meter and checking the electric light bill) are of this nature. Students' observations and results may then be discussed in class.

3. **School Experiments Extended to Home Exploration.** Certain experiments will take more than one class period and thus need the kind of planning all sustained activities do. There are several types of sustained activities in *You and Science.*

Hobbies In Science. Such sections, of several pages each, follow many of the units of the text and are organized under specific content, leading to further interests in biology, chemistry, or physics —courses most likely to follow *You and Science.* Among these are:

Rocketry (text page 203)
Chemistry (pages 346-49)
Living Things (pages 425-33)
Model Airplanes (pages 527-31)
Photography (pages 580-85)

Our observations of the use of the first edition of *You and Science* indicate that these hobby sections have real interest throughout the country and extend science as a sustained activity into the home. Due to their variety, they appeal to pupils of wide diversity in gifts and opportunities.

On Your Own. The launching of space rockets and satellites and the imminence of space travel have greatly heightened interest in the geography of space. The section beginning on text page 625, entitled "On Your Own," is a sustained hobby section that can be used as a science club activity or pursued by interested groups of students. It can be started at any time—at the opening of the term, with Unit Three, or at any other time—and continued through the year or as long as there is continuing interest. Incidentally, the two preceding books in the *Science for Better Living* Series contain similar sustained activities: *You and Your World* explores magnetism and electricity, and *You and Your Resources* introduces the student to simple discoveries in chemistry. Students whose interests were awakened by these earlier activities should be encouraged to continue them on their own if they wish. Three or more long-term science activities may thus be going on at one time during the year.

Research Activities. Following each chapter is a section entitled "Going Further," where you are likely to find an activity

which will send the pupil on a search. He will need to consult books or people, do an experiment or project, or analyze a bit of data which will call for more information. Most of these research activities are in reality quite simple, but a few are considerably more extensive.

For instance, "Model Rockets as a Hobby," on text page 203, can lead to a project for an exhibit later at a science fair. So, too, may the other hobby sections and "On Your Own" mentioned above. An award-winning entry in a local science fair may later be exhibited in a county or a state fair and possibly be worthy of entry into a national exhibit or contest.* It has been found that the earlier a student begins work on a science project, the more likely he is to be successful in winning a major award in later high school years.

4. **Projects**. All the above might be considered projects, but for some reason the word "project" has come to mean "making or doing something toward a specific end," e.g., a magneto, movie, chart, or collection. These can be initiated in class, and may be continued in a laboratory or at home. Such projects are to be found in the following sections:

a. "Going Further," under the headings "In the Laboratory," e.g., growing *Penicillium* (text page 116); and "A Bit of Research," e.g., investigation of sleep (text page 99).

b. "Hobbies in Science," e.g., making model airplanes (pp. 527-31).

c. "On Your Own"–many kinds of research projects (pp. 625-48).

d. "Built-in activities," e.g., a model (page 503); a chart (page 247, in connection with the illustration); and a device (page 510).

5. **Just Experiences**. Other activities are difficult to place under a specific heading. For instance, collecting specimens of living things (text pages 425-27) may involve project work, research, and experimenting. So may other activities suggested under the four sections cited just above. Even the three full-color sections, *Atomic Energy*, at text page 288; *Corn—A Seed Plant*, at page 400; and *The Frog*, at page 432, may suggest extension into various activities.

Essentially, since teaching is a personal invention, each teacher will use those ingredients which best fit his methods, his plans, and his opportunities.

*The Westinghouse National Science Talent Search conducted by Science Service is an example. For information write Science Service, 1719 N Street, N.W., Washington 6, D.C. Other national contests of this type are conducted by Future Scientists of America, 1201 16th Street, N.W., Washington, D.C.

6. Field Experiences. Exploring in the field is suggested throughout the book. Field trips to collect living things (text pages 425-32), photography in the field (pages 580-85, pages 633-34), etc., are included. Throughout this Manual, other suggestions for field trips are offered. In addition, see the "Index of Experiments and Activities" (page 697) for many suggestions.

The teacher may be further guided in preparing for a field trip through such references as pages 490-92 of *Teaching High School Science: A Book of Methods* by Brandwein, Watson, and Blackwood.

ORGANIZATION OF THE TEXT

Much of the time of a scientist is spent in reading the work of others, a fact that is often overlooked. Reading should be accorded the same status as doing experiments and projects. A textbook is an instrument which starts with reading but is a teaching tool whose recounting of the adventures of science is meant to evoke many kinds of activities other than reading.

To be an effective instrument, a text should have an organization that encourages the best use of reading skills and learning techniques. Thus, *You and Science* has an easy-to-follow organization:

1. The Unit. Each unit in the text is a major area of discovery in science. We might say that the unit is the framework around which related concepts are built into a conceptual scheme.

2. The Chapter. Each chapter is itself also a grouping of smaller concepts into a conceptual scheme which is a part of the major unit concept. For the purposes of the learning level we shall consider the sections within each chapter as concepts. These sections are indicated in the larger boldface capitals. Each section title and the introductory paragraph following it suggest the concept. The text then proceeds to *define, develop, use,* and *illustrate* the concept, presenting essential facts that support the concept. Understanding of the concept is then tested in the end-of-chapter material, as well as in the test booklet accompanying the text. Whenever possible an activity stemming from the concept, or supporting or extending it, has been included. Also, life experiences or applications have been built in.

Thus, in presenting reading and learning skills it is quite proper to ask of the pupil: What facts are in this paragraph—or this section? How are they related? (Relating of facts leads to a concept.) How are the ideas in each section related to the central idea of the chapter? (The pupil moves toward a conceptual scheme in science.) What are the big ideas in this unit; for example, Unit 3, *"Exploring the Earth and Space"*? The organization of *You and Science* and the planning of its units, chapters, and sections enable teachers to

wh ctly into the student's nervous system large ideas about -r onment and the universe in which he lives. Facts are not themselves but the means to understanding.

ections as Teaching Units. Each section, in addition, may be taken to be the central idea of a lesson or of a lesson pattern of one or two days—rarely more. Each section is meant to be read within a half-hour; this includes the taking of notes. That this scheduling is realistic was found in a study of pupils who had been using the previous edition of *You and Science*.

The sections, each a subdivision of a chapter, are graded in length and difficulty. They begin with simple facts and concepts but become more complex and require more analysis as the term goes on. That is, the pupil makes more complex relationships as he becomes familiar with an increased body of information which he can organize and build into new concepts.

BUILDING CONCEPTS

Concepts are built up in five ways in each section of each chapter:

By information: The text presents confirmed facts and information which will give the pupil a base for making relationships or for developing the pattern of facts that make up a concept.

By building up a vocabulary of science: Where first used, each new scientific term is defined, pronounced, and used in the context of an experience.

By experience: A concept is developed or illustrated by frequent built-in experiments, by photographs, by drawings—in short, by experiences which develop the concept in different contexts.

By extended activities: End-of-chapter suggestions, the "On Your Own" section, the hobbies in science sections, and other activities proposed in this *Teacher's Manual and Resource Guide* provide a full and rich program for developing and extending concepts already presented in the text.

By testing: Understanding of concepts (and the tool words which define them) is developed specifically in three ways: by a short built-in pupil self-check at the end of chapters, by review of the key words, and by two booklets (Forms A and B) of chapter and unit tests (see Manual pages 34-41).

Of course, each teacher will select the kind of materials most useful for his individual needs or the alertness of his class. It is not intended that all materials be used with all classes or at all times. The total program of activities can be looked upon as a testing program and as a teaching program. After all, any experience in which a pupil puts together previously acquired knowledge or concepts into a new relationship is a form of self-test. Testing,

in other words, need not—and should not—always be a formal situation.

USEFUL APPROACHES TO STIMULATE READING

The subdivision of the text into units, chapters, and sections is a typographical and organizing device (as well as a teaching aid) that enables pupils to follow the textual content in an orderly sequence. However, more than such a mechanical device is needed to stimulate the desire to read. We believe that reading can be stimulated by the manner and style in which a text presents its content. We have used the following writing approaches throughout *You and Science.*

1. The Personal-Interest Approach. One recognized and accepted way of stimulating young people to read or to do is to tap their personal interests. Unit 1 of *You and Science* is given over to a survey of the ways of the scientist and the ways students learn as they engage in the processes of discovery in science. Careful presentation of this first unit may well lead to awakening interests but more especially to a questioning attitude and an awareness of the importance of accuracy in science that will expand throughout the year and on through high school and college.

Turn to almost any page of *You and Science* (such as pages 70-72, Balanced Diet for Balanced Growth; 185-202, Space, Our New Frontier; or 290-311, Splitting the Atom) and you will note the appeal to the curiosity and personal interests of the students. The "You" in *You and Science* points up relationships of science to personal living.

2. The Story Approach. Frequent biographical sketches and descriptions of the work of scientists are given, as, for example, Eijkman and Goldberger (text pages 66 and 67), Fermi (pages 294-99), and Salk (page 108).

3. Visualization Through Pictures and Color. The text has many illustrations that illuminate concepts, reinforce ideas, and encourage interest in science and the work of scientists. Young people tend to read books that are "visualized." Note, for example, the two picture stories in Chapter 1, "Tools of Investigation" and "Adventure in Science" (text pages 16 and 17), which give young people an insight into two sides of a science career. Each chapter opens with an illustration and three lines of text to attract the student's attention to an important idea.

The use of color helps to draw the pupils' eyes to the essential or significant points in a drawing. Contrast of color and black and white aids visualization and thus helps to teach in science.

Note particularly the three full-color sections on *Atomic Energy*, at text page 288; *Corn—A Seed Plant*, at page 400; and *The Frog*, at page 432. The student is at an age when he wants to know "how things work." He wants to know, for example, how atoms can release the energy to run a power station, how plants make food, or how animals move and digest their food. These full-color charts visualize for him better than many pages of words one of his major personal interests at the junior high school level.

4. **Science Inventories.** Each unit opens with a photograph and a brief statement illustrating the general theme to be developed (see Part B of this Manual for unit themes). A logical query of a student might be: "How much do I know about this subject?" Hence, a series of questions probing his general background and experience is given to indicate to him—and to his teacher—the type of exploration he is about to make and how much he knows about the area. The inventory helps to direct his attention as well as stimulate interest.

5. **Reading Level.** Not only have the vocabulary and sentence structure been carefully checked against standard lists and reading scales such as the Thorndike, Buckingham-Dolch, and Dale-Chall, but the reading level has also been checked by expert teachers and samples read and commented upon by children on the grade level of the book.

The text of *You and Science* has been developed, therefore, to serve the teacher in giving the student a picture of himself and his world. This is done by blending all the learning experience which master teachers make available in their classrooms.

CHAPTER 3: FACTORS IN CLASSROOM PLANNING

Teachers agree that there is so much to teach and so little time to teach it. Studies show that successful teachers do not attempt to teach everything. They select carefully, and teach thoroughly what they select. In short, they do not do *all* experiments, but those they do are done with controls wherever applicable. Selection of topics for study during the term is based on both pupil and teacher interests, on objectives of the course, and on such considerations as the availability of materials, demonstration and laboratory space, current events, and many other factors.

The teacher planning for his course will be influenced, no doubt, by such factors as current happenings, pupil interest or curiosity,

suggestions of fellow teachers, reference books, and i tive ideas—all based on previous experiences and the sp the pupils in the current term.

THE TEACHING APPROACH

There is all the difference in the world between teaching science as a way of solving problems or satisfying one's curiosity and teaching it as a repository of absolute information coupled with formal answers to formal questions. Put another way, there is all the difference in the world between using subject matter as an answer to problems or as an end in itself. Let us illustrate: We may start with a demonstration to show the effect of saliva on soda crackers. Saliva is mixed with a starchy material; after a short time a test with Benedict's solution reveals the presence of sugar. The class can record the procedures and steps that lead to the final observation and obvious conclusion.

The teacher can now do one of several things, depending on his answer to these questions: Should he now go on to the next topic on digestion? Should he ask for pupil comments and questions? Should he point out some of the shortcomings of the demonstration? Can he ask searching questions which will provoke pupil thought? A pupil may be curious enough to ask whether the saliva used might not be contaminated with sugar; shall we check on this? Or perhaps a starchy cracker contained sugar; shall we check on this? Even if there is no evidence of sugar in either saliva or soda crackers, can we conclude from this single demonstration that everybody's saliva contains starch-digesting chemicals? How shall we check this? In this way the students have turned a demonstration into an experiment, guided skillfully by an alert teacher who is ready to exploit a situation which lends itself to real learning. Perhaps we should clarify what is meant by "experiment" as contrasted with "demonstration" in this discussion. A demonstration is done once; an experiment is done several times to test the different hypotheses suggested by students, even if the teacher knows that the way the student suggests the experiment be done undoubtedly will not work. Whenever possible, the teacher encourages pupils to think actively by stimulating their curiosity and giving them an opportunity to find out for themselves.

Problem-doing and Problem-solving. Problem-doing is the fate of the classroom demonstration which must be done, finished, and wrapped up in the 40 minutes of a class period. The saliva-starch demonstration mentioned above started with the statement of a problem. Problem-doing then followed in a formal way, especially if the teacher did not stop to encourage questions which might lead to the investigation of other problems.

While the problem-doing found in workbooks and the problem-doing of the formal demonstration or experiment reconfirm concepts, the problem-solving of scientists might be called "concept seeking." In problem-solving, the statement of a problem is a creative act, a sort of key operation based on preliminary work; the clarification of the problem is just as important here as reaching a hypothesis, developing a piece of important equipment, or reaching a conclusion. The saliva-starch activity which started out as problem-doing became modified to a problem-solving situation when new problems were raised and clarified, and cautious conclusions were reached. Drawing up plans for investigations and checking them with a large number of pupils required precious time; perhaps some additional topic intended for discussion the following day had to be postponed, or even canceled. But an active "sciencing" situation took place in the classroom as queries flew back and forth—from teacher to pupil, from pupil to pupil, and finally, from pupil to teacher.

This is not to say that problem-doing has no place in science-teaching. Inasmuch as the content setup of our present general science courses reflects to a large degree the history of science (an exposition of the observed facts, concepts, and accomplishments of science), problem-doing is an important technique that belongs in the classroom; problem-solving, or concept seeking, is also an approach which can be accomplished in the science class. Pupils can engage in both.

In summary: Concept formation consists of problem-solving as well as problem-seeking which will lead to a group of similar elements or related facts we call a *concept*. On the other hand, in problem-doing the chief stress is on the use of technology, usually as an end in itself. Although automatic repetition of a procedure, if followed in logical steps, will come out exactly as planned and *verify* a carefully stated problem in expeditious, time-saving techniques, it will not lead to the *formation* of concepts.

Concept formation is the aim of many teaching activities you have used in the classroom. There is drill, for instance, to develop skills such as solving problems related to gravity effects on the moon and Mars, or writing the chemical formulas for water and carbon dioxide. There is review activity of large concepts as they are applied. There is the field trip activity, the film activity, the skill activity in the laboratory such as handling a microscope or glass equipment. But these are all means to an end, learning procedures which themselves lead toward active concept formation. In any event, problem-doing and problem-solving help students both to identify *and* to understand the ways of the scientist and help them also to use the various methods he employs.

PHYSICAL CONDITIONS OF THE SCHOOL

In planning your general science course consideration should be given to the possibility of laboratory work—or limited laboratory work. If the physical conditions of the room are unsuitable, can there be some improvisations which will permit laboratory work? The chapters which follow offer suggestions that may help you to do some student experiments (with pupils working in groups, in pairs, or by themselves), even though your room may be an ordinary classroom, rather than a laboratory room.

If the course is to be a classroom course only, then you will want, no doubt, to allow for the sharing of experiences through demonstrations. You will need to determine how much of a role pupils will play in a demonstration. Actually, every pupil participates, in one way or other—thinking actively as the demonstration is planned and as it proceeds, or, if given the opportunity, handling the equipment and actively assisting the teacher (or having the teacher assist him). In short, the demonstration is an integral part of the lesson; its major function is to present evidence for a concept by doing, observing, and testing. Although the demonstration is not a substitute for individual laboratory work, it becomes a group laboratory experiment in which selected members actually do the experiment, while all observe carefully and suggest procedures, devices, controls, and safety precautions. All pupils take notes and are expected to use, in later work, the knowledge gained.

ADDITIONAL TEACHING TOOLS

In planning the course you should consider *all* the available teaching tools you will employ for natural and meaningful concept formation. In this Manual, we shall refer constantly to such tools for the science teacher as

1. the textbook
2. classroom demonstrations
3. laboratory lessons
4. chalkboards
5. field trips
6. home assignments
7. projects, reports, and newsletters
8. films and filmstrips
9. reading references
10. library lessons
11. bulletin boards
12. teachers' references and resource materials (the *Teaching High School Science* Series* is an example of resource material which general science teachers have found useful).

VARIATIONS IN ABILITIES

In many general science classes there are some youngsters who are slow learners, others who are rapid learners, and many who are moderate or average learners. A number of schools with enrollments of 800 students or more (including ninth grade in the 6-3-3 organization) group pupils by ability. Thus, we find some general science classes composed of slow (or science-shy) learners, others made up of rapid (science-prone) learners, and still others of average learners. We shall attempt to describe the characteristics of each type. Usually, ability grouping begins in the ninth grade, although there is an increase in such grouping in the seventh and eighth grades.

1. The Science-Shy. Although the student so designated may be "slow" in science learnings, he may be quite adept in other areas such as playing a musical instrument, fixing an automobile engine, social sciences, or progressing in literary arts. We recognize the fact that poor achievement in learning science, as in any other area, is due to many factors. Here are several, none of which operates alone:

I.Q. The achievement of a pupil in a science course is generally related to his intelligence as described by his I.Q. Science courses stress many of the same qualities as do intelligence tests: ability to organize and retain information, high verbal and mathematical facility, fairly quick reaction time, and success in paper and pencil testing. If students with large differences in I.Q. are placed in the same science class and subjected to the same standards, that is, expected to attain the same goals to the same degree, pupils with low I.Q. scores will show up to be "slower" in their learning accomplishment.

Although, as we have mentioned above, science-shy pupils are not necessarily slow in other fields of endeavor, many science-shy students are those usually called "slow" learners. These pupils may be poor in science as a result of a lack in mathematics or a deficiency in basic reading skills, in intelligence, or in any combination of the three. From this we can see that the science-shy pupil is likely to have difficulty with abstractions, or with memorization of materials not put into almost immediate use in his daily life. His attention span is likely to be short (he is readily distracted), he is not consciously bound for college, and he may not even finish high school. In short, he is limited in his ability to grasp major science concepts.

**A Book of Methods; A Sourcebook for the Biological Sciences;* and *A Sourcebook for the Physical Sciences.* Other book references are listed at the end of each unit in Part B and at the end of the Manual.

Interest. Given adequate motivation, a pupil will *want* to know more about a given topic. If he wants something and his general science course helps him get it, he will be more likely to learn to the best of his capacity. A pupil who is referred to as "slow" may be slow simply because he lacks the interest and desire to learn.

Nature of the Course. The nature of the course can determine the extent of pupil-success. A course in general science which relies on memorization of minute details (such as the fine points of anatomy; the detailed bones of the ankle and wrist) may not interest the student as much as one which deals with aspects of the body important to him in his daily life—nutrition, disease, body physiology, heredity, and reproduction.

Elementary Science Preparation. Children who come from elementary schools where little science is taught (or where science is chiefly nature study) lack the background to achieve as high a degree of success in science as pupils with an adequate background in elementary science. Or a student may be predisposed *against* science because of elementary courses, home experiences, or other factors.

Other Factors. The other factors which can cause science-shyness vary in degree. The prestige of science in the socio-economic group from which the student comes is important. So, too, are attitudes of the administrative officers, the guidance program of the school, the science interests and preparation of the teacher, and the nature and extent of the teaching materials. The extent of the remedial program to correct weaknesses and the attitude of his fellow students also need to be considered. All these factors have a bearing on whether a student will be science-shy, science-prone, or average in science learning.

2. **The Science-Prone.** Pupils with a high level of ability in science will be recognized, to some extent, by their performance in class, as well as by their interests and attitude. Their ability will be expressed most favorably in an environment which provides a rich educational diet. The characteristics of the science-prone child are reflected in the factors which influence his behavior. These boys and girls are from two to three years in advance of their groups in verbal and mathematical ability and skill. At the ninth grade, for instance, the records of these children often show, in general, the following indications:

a. A reading score as high as the twelfth-grade level (using a standard test).

b. An arithmetic (or mathematics) competence score as high as the twelfth-grade level (using a standard test).

c. An interest in science begun early (in the fifth or sixth grade) as shown by: (1) hobbies (radio, tropical fish, astronomy, etc.);

(2) reading (*Science News Letter, Science Digest, Popular Mechanics*, etc.); (3) types of television programs they watch (scientific and technical programs).

d. High grades in earlier classes they have had in science—average near 90.

e. An average total score of near 90 on tests similar to those which accompany *You and Science*, the last book in the *Science for Better Living* Program.

Some of these indications of future ability may be readily spotted in earlier grades; for example, these pupils will get generally high grades in science and on the tests which accompany *You and Science*.

Of the factors associated with the science-prone student, many are readily evident by the ninth grade and indications may show up or be suspected as early as the seventh. Among these are:

Genetic Factors. As used by Professor Terman of Stanford University, these refer to characteristics with a base in intelligence and general muscular control, which are now accepted as hereditary traits. High verbal ability and mathematical ability appear to have a relationship to high intelligence. However, by themselves, these factors do not guarantee success in general science classwork, science studies, or scientific research. Apparently, there are some factors which help to influence high achievement in science, as well as in other areas.

Predisposing Factors. One basic characteristic of the science-prone child is *persistence*, usually shown by developed attitudes such as willingness to spend time beyond that required for a given task, to face an initial failure, and to return again and again to a given problem to find a solution. He also has a drive so strong that he is willing to endure fatigue, strain, short lunch hours or none at all, etc. His ability to show an investigative attitude, to strive for further explanations of a given problem, to seek additional statements which will corroborate or refute some present explanation rather than simply accept authoritative statements—all these indicate his determined approach and desire to quest for knowledge.

Activating Factors. All of us have been influenced at some time or other by people, places, and happenings. With the science-prone child, one very important person can be an *inspirational teacher*; he can "bring out the best" in a child by kindness and sympathy, by stimulating teaching, and by suggestions for further, enriched approaches in science. A warm, dynamic personality can generate enthusiasm in youngsters both directly and indirectly. For a useful treatment of the entire subject of science-prone children we recommend *Teaching High School Science: A Book of Methods* by Brandwein, Watson, and Blackwood; the bibliography at the end of Chapter 9 details some 100 papers which will help

the teacher to understand more about children of high-level ability.

3. **The Average Student**. The average or moderate learner is one of a vast group of children whose limits at one extreme border on the science-shy and at the other on the science-prone. Most teachers tend to direct their teaching efforts toward this middle group, whose characteristics are quite variable, and hence, quite difficult to define in precise terms. Some would place students into this group on the basis of an "average" I.Q. (a range of 90 to 110 is sometimes used) and "average" results in reading and arithmetic accomplishment or achievement tests for the grade level where the pupil is expected to be, or in the spread between one year below or above this level.

The so-called average pupil may show at times a pattern of behavior so inconsistent that you wonder whether you or the school "placed" him in the right category. Some may show occasional flashes of insight and accomplishment which might place them with the rapid learners; others, it seems, may suddenly take a nose dive in their school work, attitudes, and ambitions and appear to be on the border line of "slow" students. The pupil, at this age level, may be going through intense physical, mental, and emotional developmental changes which often affect his behavior and performance—both in school and outside the classroom, as many parents will sorrowfully admit. The achievements of the average student in school will be greatly influenced by his teachers, the nature of the curriculum, the attitudes of the community and his parents toward schools, by his fellow students (social pressures), and of course, by his own personal ambitions, whether these involve a job, college preparation, or no goals whatsoever.

TIME ALLOTMENT

How much time you will allot to a given topic will vary with such considerations as the background and mental maturity of your pupils, the nature of the school and community, and most of all what you select for emphasis on the basis of how much you know about your students. The patterns in courses of study are so variable that it is hazardous to suggest a fixed time schedule for *You and Science*. If the students have had a fair amount of science instruction in earlier years and from four to five periods a week are available for this full year, then we can suggest what can be done by citing a time-allotment schedule used in a number of educational systems that have used the first edition:

	Periods or Class Meetings of 45-55 Minutes
Unit 1	7-11
Unit 2	19-23
Unit 3	19-23
Unit 4	21-25
Unit 5	23-27
Unit 6	19-23
Unit 7	23-27
Unit 8	19-21

The above allotment is based on five class periods a week for a school year of 36 weeks. If the minimum time scheduled in the allotment above is used, thirty periods are made available for the expansion of any unit or of several of them. It is likely that allotments will vary between minimum and maximum for different units, depending on the interest and background of the students at the time the units are being studied. Variations in the allotment can be planned at the discretion of the teacher. At no time should you feel that you must follow the progression of units as set forth in *You and Science*. Nor is it essential that you cover every unit in the text or follow the units in a set order. If your school has a fixed course of study for the grade, you can readily stress the units and the sequence that meet your course. If your course of study is permissive, it is suggested that you attempt to discover the interests of your students and stress the units and chapters that carry your students the furthest along in science. To this end you will find the science inventories that open each unit helpful in making your time allotments for particular units; some units you will wish to cover in detail and others you may wish to go once over lightly.

Should you find that students' interests or background make extra periods available, you can cover certain units with greater thoroughness by encouraging individual or committee projects, sponsoring science club or science fair activities, and dipping into the many suggestions in Part B of this Manual. A time allotment should not be imposed by a text but should grow from the needs and interests of a class.

CHAPTER 4: SPECIAL PROBLEMS

In Chapter 3 we discussed some of the characteristics of the science-shy, the science-prone, and the average pupil. Once these pupils have been identified, an approach to teaching each type of

student can be considered and developed. The purpose of this chapter is to offer suggestions of particular pertinence to teaching *You and Science* with pupils of different abilities and interests.

TEACHING THE SCIENCE-SHY

Success with the slow learner begins with the attitudes and approaches of the teacher, who is the key in limiting or extending the progress of the pupil. If memorization of facts unrelated to life situations is stressed, the slow learner may readily be outstripped by pupils with higher capacity to retain subject matter. The slower pupil cannot persevere under these conditions; he will patiently (or impatiently) mark time until he drops out of school. He often tends to categorize himself as a failure and to feel that his fellow students think likewise (unless he has achieved status elsewhere—e.g., athletic success). Before specific suggestions for teaching the science-shy are given, let us consider a few approaches that may help encourage these pupils and even awaken them to put forth unexpected effort to overcome their shortcomings.

Approaches in Motivation

1. *Guidance*. Nowadays children must remain in school until a certain age (16 in many states). The pupil can be helped to understand himself through individual conference or group guidance about such topics as: kinds of jobs available after he has finished school, the purpose of school, how to get along with certain teachers, how to memorize more effectively, how to study more effectively, what subjects to take next term, and many others which bring about a better rapport between teacher and student, between student and counselor. The problems of shyness, aggressiveness, failures, jobs, disciplinary situations, etc., can be discussed at individual sessions. Pupils who see that teachers care for them, show interest in them will, in general, respond in kind and show appreciation for kindness.

2. *Planning*. Pupils who have been carefully counseled (and begin to understand the reasons for their failure) gain confidence in planning their own individual work, both now and after school. The work to be studied in the current term can be planned by cooperative effort of pupils and teacher. The teacher may suggest that a preliminary topic be studied as foundation material for one suggested by pupils. Often these topics will coincide greatly with topics elaborated in *You and Science*, for the units in the text are based on pupil interests in the first place.

3. *Special Curricular Design*. Slow learners are interested in

science and can succeed in it if the course is shorn of detail which is meaningless to them, as, for example, detailed classification of plants and animals, detailed anatomical parts, chemical formulas, and the like. The make-up of man is more significant than the anatomy of an earthworm, and the chemistry of common chemicals found in the home is more interesting than the laboratory preparation of a gas such as oxygen.

4. *Special Teaching Patterns and Techniques*. In order to get slow learners to work to the best of their ability and at the same time to gain faith in themselves, teachers may need to alter the methods they use for moderate or rapid learners. For example, it is difficult for slow learners to engage in a span of attention of forty or fifty minutes, particularly if listening and some discussion is called for. Breaking the class period into several different types of activity may be beneficial.

The detailed chapter-by-chapter suggestions in Part B of this Manual provide some specific suggestions for teaching the science shy. Some of the activities stressed include reporting, drawing, experimenting, field trips, games, collecting materials for bulletin boards, hobbies, and—very important for these pupils—reading.

Variations of Activities. Slow learners appear to work best in teaching patterns in which activities are varied frequently enough to maintain interest and attention. Thus a lesson might begin with supervised study, go on to a discussion, then to a demonstration or experiment. What is being suggested is that the activities within any class period be varied in order to capture the shifting or flagging attention of all the youngsters. Actually, this is a good practice, it has been found, for all kinds of classes, but most especially for young students. The text (one of the teaching tools in any approach with youngsters) helps introduce variety. For instance, in *You and Science*, each chapter is divided into sections, each around a major idea, and each section is illustrated with visualization in mind. Wherever possible, each section includes an activity or is built around an experience. What we try to do is to get into the student's nervous system in every way we can. In other words, the text attempts to fit into as varied and flexible a teaching pattern as possible.

Activities—either those in the text, those evolved by the teacher in his previous classes, those suggested in this Manual, or those suggested by pupils as a result of having had their curiosity (a concept-seeking desire) aroused—will go a long way in introducing a lesson, maintaining the ideas of the lesson, and finally, extending the lesson. If interest has been maintained, especially if the work has been significant, the classroom activity will be extended into the home and the outside environment which the pupil shares with his friends. This extension may take the form of an assignme

or a project, or some self-initiated work. An "impromptu lab" may be set up in a basement or garage or in a corner of a classroom where some private investigation can go on. For some youngsters this lab may hold many items, from test tubes to chemicals; for others it may have just a small growing plant and a place to do their school work. Some of these students may even find the "On Your Own" section on skywatching appealing enough for them to make real progress—even though they may be unable to complete all the projects in the section. Nor is it necessary that the projects be taken in the order presented.

Working with Others. The science-shy (as well as others), wherever possible, should have opportunities to work with others and make contributions to the class. Such contributions as home-made wall charts, diagrams and materials for the bulletin board, participation in committees, assisting in class demonstrations, and other activities enumerated in Part B of this Manual can be of help to the entire class.

Keeping Written Records. Science-shy pupils should be encouraged to keep some form of written records; here you as the teacher will have to decide the most feasible approach. You may want to set aside part of each period (not necessarily the last portion) for visiting with as many individual students as possible, and making suggestions to guide them in their note-taking and summarizing of class activities.

Problems in Reading. An extremely important activity, reading, has been left to the last in order to emphasize its importance. Inability to read, it is known, is one of the main reasons for "slow learning." Certain techniques to improve reading ability are especially helpful to use with the science-shy—and perhaps with others:

Obtaining the Main Idea. Being able to get the central idea of a paragraph and to pick out supporting details are accomplishments which can be mastered by slow readers if they are given the right help in class. In fact, these are basic skills for success in any learning that involves content obtainable from books. There are various techniques to discover the children who have difficulty in reading.

One useful procedure is to ask students to turn to a given page, soon after they have received their texts. Ask them to read quietly a given paragraph, possibly one on the topic under discussion, and to look up when they are done. Then ask them to write the major thought of the paragraph in one short sentence. Most students—even the moderate and rapid learners—will find this very difficult to do at first. However, after students have read the next paragraph, most of them will be able to word its major thought in one short sentence. If you then ask the students to write down in

sequence the major thoughts of several paragraphs, you will be able to determine who can read with a fair amount of facility.

One teacher may do it this way: He goes around as each student writes down these major thoughts and determines who has difficulty. He tries to detect the nature of the difficulty by talking with the student. This talk plus the evidence of the efficiency or deficiency in the work done will give the teacher an index of the pupil's ability to read.

Couple this information about students' reading abilities with their scores in standard reading and arithmetic tests, I.Q., and previous record, and the slowest students in the class will be detected. Furthermore, the underlying reasons for their "slowness" may be nearer to determination.

Of course, you may want to use a motivating activity to stimulate interest in the supervised reading session. Often a demonstration, a film or filmstrip, a field trip, a current events item brought to class, an experiment, or a discussion of a pupil's hobby or other interest may arouse students' interest and curiosity to a point where they may want to explore a given problem further by discussion in class, which then leads to reading research

Experience has shown that if students are given practice in getting the major thoughts of what is read by having such supervised study lessons at least once a week, their reading will improve; they will gain confidence in their ability to read, and thus learn. As all pupils learn to read better, the amount of time they need to complete a certain homework assignment will be cut considerably; their studying efficiency will be improved, and the efficiency of the entire class will be higher.

Interpreting Drawings. We have seen that the printed thoughts spelled out in a book must not only be seen by the child, but in addition, they must be *comprehended* by him. When a radio operator, or teletype operator, or navy signal man sends a message—whether verbally or in signs and symbols—he asks, "Do you read me?" Don't we also *read* an expression on some child's face? Or *read* a weather map? Or *read* the footprints of animals in the sand around a water hole? *Understanding* what we see, rather than just looking, is the true meaning of reading.

Getting the science-shy child to read or correctly interpret a drawing calls for careful planning on the part of the teacher. Children can be aided in the interpretation of drawings by class discussion, or by placing before them key questions, directions for further investigation, models, and actual specimens, as well as by the nature of the diagram itself. For instance, the diagram of the mammalian heart on page 92 of *You and Science* is in two colors: red and black. But in addition, the right side of the heart is colored brownish-red to connote blood relatively deficient in oxygen (although the caption does not say so specifically).

Interpretation of the drawing may be expanded further by calling the pupils' attention to the fact that the valves between the ventricles and auricles are open when the ventricles are relaxed and closed when the ventricles contract. The suggestion in the text that a sheep or beef heart be obtained from the butcher will add still more information: The actual specimen will be easier to follow with the aid of the diagram, and the diagram itself will take on more meaning when compared with the three-dimensional specimen. The drawing can be interpreted further with the suggestions given on Manual page 68. When the sheep's (or beef's) heart is brought to class, the teacher can make a partial, lengthwise incision to reveal the chambers; then, separate red and black rubber tubing can be passed through the chambers and valves so that the slower child can trace two complete cycles of blood passing through the heart.

Nothing can be more boring to children, after a while, than repeated copying of drawings and diagrams from a textbook into their own notebooks; they should be given the opportunity also to analyze and discuss fully the significance of each diagram. You will notice that most of the drawings, diagrams, charts, graphs, and photographs in *You and Science* have provocative questions associated with them, either in the caption or the accompanying text.

Children need help and encouragement in interpreting complex drawings, especially graphs. For example, on text page 111 is a graph showing the death rates from five diseases in 1957 as compared with the rates in 1900. Blue and black arrows on the graph call attention to the upward or downward incidence of these diseases during these years. Rather than describe what the graph shows, the authors are trying to make the student do more than just "see" the information on the graph. This they do by trying to make the student follow the graph and think out the answers to five short questions given in the caption. Further help in interpretation should follow in class discussion, the teacher encouraging additional questions with comments by other students.

It is often helpful to place an enlargment of a diagram on the chalkboard. (Perhaps a slow learner would enjoy making one on cardboard for your teaching file.) The use of colored chalk during class discussion will make the graph take on added meaning. Interpretation of drawings may raise additional problems for discussion. Further readings may be necessary to help answer or "solve" them.

The "reading" of drawings, diagrams, and graphs is an essential skill in science. The main ideas are in the drawings, but the supporting details often grow out of discussion and lead to an enlargement or enrichment of the idea. Critical and constructive discussion of drawings is a great aid in concept formation.

Using the Parts of a Book. A reading assignment given by the teacher may call for competence in the use of the text or other references. Some important points may have been brought up in class discussion by other pupils; the teacher may want the group to answer these questions. If the student knows how to use the table of contents, the index, the glossary, and the hints afforded by the boldfaced or italic headings, his reading research will be made simpler. Extension of the "indexing" skill in using these parts of a book leads to greater facility in the use of the *Readers' Guide to Periodical Literature* and the card catalogue in a library to locate simple science books (such as other textbooks for the same or a lower grade level) and trade books written in a simple style and with a minimum of vocabulary obstacles.

Following Directions. Many pupils at this level, not only slow learners but average and occasionally better students as well, have difficulty in following directions. Essentially this skill is related to that of selecting main ideas and supporting details from a welter of details, some significant, others not. But a new dimension is added: the student is required to do something, to follow steps in a procedure in an orderly fashion. The built-in experiments, used in the classroom under simulated or actual laboratory procedures, offer training in this essential skill. Pupils should be encouraged to check each step to verify facts or procedures. Class discussion should be encouraged, especially if the results obtained vary greatly from pupil to pupil, to help pupils to work together co-operatively and discover both the need and techniques for achieving a reasonable degree of accuracy in following directions.

Often steps in a procedure are implied rather than set forth in specific detail. Training in following directions aids students to set up their own steps in organizing procedures or in seeking further information. For example, the caption of the illustration on text page 150 asks the student to write a paper on the question "Are There Men on Mars?" The student must seek the answer in the text. On the same page he finds some information about conditions on Mars. But will these conditions support life? On pages 146-49 he finds information that will help him draw a conclusion. The slower student may stop here, but the brighter student will not be satisfied. He will want to ask questions—perhaps through class discussion but more likely by reference to readings listed at the end of the chapter or others which you may be able to suggest to him. Reading, for this student, is research in search of meaning in order to enlarge a concept. In a word, the question asked in the caption for the illustration implies a form of direction requiring organization of a procedure: the student must ask questions that lead to a procedure that in turn leads to further questions that he needs to answer before the original question can be satisfied

Of course, there are different levels of satisfaction, depending on the questing capacities of the student.

As we have mentioned previously, pupils trained in a plan of reading involving directions will not waste time as they go from page to page. In giving directions for a reading activity, the teacher, to make certain that all his students know what he has in mind, may ask a pupil to read the question that was placed on the board and then ask another pupil to explain what steps are needed to arrive at an answer. The teacher can ask the class if they, in turn, have any questions to ask. If ambiguity is removed at the start, the class will be better able to go about their reading research.

Developing Precision in Vocabulary. To give children new words which they can use as tools in communicating with others, it is advisable that the vocabulary be carefully controlled. This applies not only to technical terms but also to everyday words of the language which serve as context for the new tool words. For instance, the vocabulary in *You and Science* has been checked against standard word lists. The pronunciation of unfamiliar words have been made easy by the use of the pronunciation-at-sight system from Grosset and Dunlap's *Words: The New Dictionary.* The technical words have been kept to a minimum, and have only been introduced if they are to be used a number of times through the text; that is, they are essential words for developing the concepts. The usefulness of these words has been checked by carefully selected teachers throughout the country, who have read the manuscript critically.

The technical term, when introduced in the classroom or text, should be used so that meaning is conveyed to the pupil at the same time. That is, words should be learned in context and not in lexical form. Some teachers encourage pupils to keep a word list and to use the new term in a complete sentence which is meaningful to them. You will notice that *You and Science* assembles the key words to the big ideas in a chapter under the heading "Tool Words" in the "Looking Back" section of each chapter. It is suggested that students be asked to match the words with the correct phrase following them and record their selections in complete sentences in their notebooks.

The slow learner can, by practice, develop some precision in using the vocabulary of the lesson or text. Frequent repetition of the words in class, or the use of word games or word puzzles is helpful. Simple crossword puzzles constructed by the teacher or members of the class can be duplicated and circulated among students. Or they can be placed on the chalkboard in advance of the class meeting. Games like anagrams and "Scrabble" can be used by groups of children for vocabulary review. Encouraging the student to use scientific terms in later experiences—such as a

demonstration, an experiment, or a field trip—will help "set" the word in the pupil's mind.

If the science-shy child does not take to vocabulary acquisition, it is better to strive for understanding of generalizations and ideas that he, his classmates, and the teacher have developed in class. Terminology is merely a tool to be used in seeking a concept—or in presenting it; it is not a goal of a science lesson. We have seen many an average and below average student bring his store of science terms up to the level of a college science course and feel quite inadequate when it came to describing an important principle.

It is a good idea to point out to students the glossary on text pages 657-71 and to indicate its purpose. Many students do not know how to use a glossary. In teaching pupils to use a glossary, one point is often overlooked: A pupil may learn the definition given but have little or no idea of what is meant; any student who has difficulty in understanding the meaning of a glossary definition should be trained to supplement the glossary by reference to the index, which will send him back to the use of the term in its full context. In practice, a student seldom uses a glossary except to refresh himself on the precise meaning of a term. Failure to understand the meaning is a signal for more thorough review. The student should be encouraged to recognize this signal by himself.

Improving Reading Levels of the Very Slow Reader. Every teacher knows that there are some youngsters with a reading level two or three years below their "normal" level; that is, in the eighth or ninth grade they read between the fifth and seventh grade level. In the experience of many teachers it is good practice to start such youngsters with an elementary science text, not specifically labeled a lower grade text so that the youngster will not be perturbed about reading a book designed for younger children. As they learn to read by getting the main thoughts of the paragraphs in the text, they can then handle successively higher-grade texts, and finally *You and Science*. This technique may not be possible where the teacher cannot devote time to each individual student in a normal-level class. However, in schools with a large registration in science, it is possible to have "remedial" science classes organized mainly on the basis of reading ability. Teachers who have participated in this type of class instruction feel that the pupils gain confidence as they improve in reading.

TEACHING THE AVERAGE STUDENT

Many of the techniques pertaining to teaching the science-shy (and the science-prone as well) are useful with the moderate learner. Teaching the average student calls for developing ways and means of stimulating his interests and arousing his curiosity so that he will want to investigate problems further. Pupils may

want to learn for various reasons: Fear of criticism for failure from parents or classmates and desire for rewards (praise, gifts, eligibility toward college entrance, or scholarships) for obtaining good marks are some of the factors leading to an added stimulus to learn. Students may be stimulated by the very nature of a subject or the activities that are part of its presentation, especially the use or construction of many visual materials, exciting displays of scientific apparatus, and other devices such as field trips and projects. Sometimes participation in a science fair or contest will direct their efforts in a science classroom.

Many ways to introduce a topic leading to concept formation are given in Part B of this Manual. The teacher should feel free to modify, adapt, and certainly improve the suggestions offered. Often the school environment will suggest many motivating factors; for example, a firehouse can serve as motivation for the study of fire and fire safety. Pupils themselves may supply motivating materials; there are, for example, the lad who is mechanically inclined to the point of rebuilding a jalopy and the youngster whose father is the local physician, a possible source for a short talk on the health of the community, etc.

Sometimes an important news event—for example, the launching of an artificial satellite into space—may be a motivating factor. How natural it is for pupil questions to evolve into a list of topics which, with teacher-pupil planning, lead to an investigation of the earth and space (Unit 3) which will not be limited to the text material.

TEACHING THE SCIENCE-PRONE

In our discussion of the characteristics of the science-prone on Manual page 21, we stated that, although genetic factors such as high intelligence and neuro-muscular traits have a definite influence, high-level ability in science is considered to be a developed aptitude. Teachers, administrators, and parents have the additional responsibility to develop the abilities of these youngsters. If opportunities to do work in science are available to children, the science-prone will identify and select themselves. They will come forward to take part in the opportunities made available to them. To recapitulate, then: In addition to the teacher's need for identifying the bright child, there is the need to make rich opportunities available to him.

The problem is one of allowing him to go *deeper* into a subject, rather than of just assigning *more* material—*more* homework questions, *more* make-work activities, etc. For example, the "On Your Own" section of *You and Science* which begins on text page 625 will allow the bright youngster to extend concepts to his own satisfaction, further sharpen his curiosity, and make enriched

contributions to the classroom atmosphere. However, this section contains much that will appeal to any interested child, because the opportunities for extending the interest are almost limitless.

In Part B of this Manual suggestions on how to stimulate the interests of the bright student, to whet his appetite for deeper probing, are given for each chapter in the text. Included are hints for additional readings, based on recent findings; suggestions on how the science-prone child can show leadership in class activities, help develop a class—or school—science newsletter, interview people in the community or write to agencies which are distant from the school, help improvise equipment, and organize a research or discussion group, as well as suggestions on how the teacher can encourage the development of individual and group hobbies. The teacher is cautioned that successful endeavors by the high-level-ability child include encounters with "lack of success" activities; failure of an experiment or project brings him face to face with a deeper problem: Why did the venture fail? While trying to unravel the difficulties that led to failure, he will encounter the need for persistence and analysis far beyond what he originally expected. The ability to take failures from time to time and to rise above them is an experience vital to this youngster.

In short, these pupils should be given an opportunity to be inventive, to discover, to be creative and imaginative, to succeed, and to realize that failure in a venture is often a step forward. Equal opportunities in education for all children must be clearly defined: It means the chance for each individual to develop his abilities to the fullest; it does not mean that all children are to be given an identical program of instruction.

CHAPTER 5: APPROACHES TO TESTING

Any selection of tests for general science classes involves an understanding of the general nature of testing, the purposes in mind, and the kind of tests available. If the teacher devises his own tests or uses such tests in conjunction with prepared tests, he must also take into consideration the general ability level of his classes. A test designed to yield an average score of 75 on the basis of a possible 100 when used with an average class may be much too difficult for a science-shy group, thus penalizing students who are doing the best they are capable of doing.

Many books have been written on testing and many kinds of tests are available. In this Manual, we have space only for discussing the general role of tests and the specially prepared *Harbrace Teaching Tests* designed to accompany *You and Science*.

THE ROLE OF TESTS IN GENERAL

Periodic testing of pupils has certain broad evaluative purposes which might be summarized as follows:

To test achievement. The purpose of this type of test is to evaluate the degree to which a pupil has mastered basic information, manual skills, and intellectual procedures. His initial standing, his present growth, and his possibilities for future growth can be discovered from his individual test scores. Local and standardized tests, with norms, are useful to discover level of achievement.

For diagnosis. The purpose of this type of test is to uncover specific strengths or weaknesses, clarify them for the pupils, and to permit for accelerated or corrective procedures. Various tests can be used.

For predicting future progress. Achievement and other types of special tests can be administered from time to time to predict future progress on the basis of present accomplishments. Their value is in uncovering particular aptitudes so that the pupil may be properly guided.

To check effectiveness of teaching procedure. A short test given soon after a teacher has developed and tried out a new teaching technique may shed light on its effectiveness. Analysis of results may reveal weaknesses and suggest ways of improvement; occasionally it may indicate a faulty technique that should be abandoned.

TESTS FOR VARYING ABILITY

For the Science-Shy. As discussed in Chapter 3 of this Manual, poor achievement in science may be the result of many factors, none operating by themselves. Tests of intelligence, reading accomplishment (and comprehension), arithmetic, interest inventories—all these can give clues to the teacher and the administration.

At the beginning of the course the teacher will find it quite satisfying to discuss with the class the meaning of grades and the nature of testing and its resultant scores. Both the science-shy pupil and the average learner more readily accept the taking of tests when they have discussed the need for tests, have had a part in formulating the goals of testing, and have had a part in planning the extent and time of the test. This discussion is not needed before every test during the term—but an opportunity to see the importance and sample make-up of a test is particularly valuable at the beginning.

It is good to give these pupils practice in taking tests, discussing their methods of study, and having them describe their own study routines. Also, how to go about studying for a given examination can be analyzed by the group and the teacher together. As pupils come to appreciate the interest their teacher has in their welfare

(as evidenced by help in preparing for tests), a better rapport will develop between class and teacher.

Especially in large classes, the slow learner often brings himself to the attention of his teacher by his failure in tests. This may be not only in written tests on detailed information, but also in the daily classroom "tests" where discussion reveals his inability to handle concepts with which average or higher-ability students may be able to cope.

Teacher-constructed tests should allow a reasonable degree of success by these slow-learning youngsters. Questions which call for abstract reasoning, for memorized details, and for a large degree of recall (rather than recognition) will prove difficult and frustrating to the science-shy. Since these students are not college-bound, a college-preparatory type of examination is not necessary; if the same test is given to all pupils, some adjustment in grading the science-shy is advisable.

Some schools use a grading system which takes pupil ability or destination into consideration. We have given tests to slow learners so designed that their grades ranged generally from 60 to 95 out of a possible 100. On the scale used, 60 was considered the border line between passing and failing. Because of the nature of the tests and the classroom approach, the grades were tagged with the letter "G" on the school records so that the right interpretation could be made ("G" stands for "General" course, as contrasted with classes for moderate and above-average learners). We also found that slow learners in heterogeneous groups could be given adjusted "G" grades, based on their relative standing in the class. Sometimes, a different type of final examination can be given the slower youngsters in a "mixed" class, with the "G" letter affixed to the grade.

For this type of pupil, asking for brief one- or two-sentence summaries of the central ideas developed in a lesson or in a paragraph can serve as a testing device. In other words, all tests need not be of the objective type. If the *Harbrace Teaching Tests* to accompany *You and Science* are used, many questions can be modified by the teacher for the slow child, or a grade assigned accordingly.

For the Moderate Learner. Just as most science teaching is directed at the average learner, so a testing program—an integral part of any teaching method—is developed to fit a normal distribution.

Tests can be designed to measure recall of facts, measure ability to recognize facts, measure skills (such as the laboratory test in which the pupil performs a task, e.g., wiring a simple electrical circuit, and is graded by the teacher), or measure the ability to reason. Prior knowledge and experience will be needed by the pupil when he takes a test which includes items calling for reasoning

An example might be a question on the use of the compound microscope: Let us assume that pupils have been taught that the total magnification of an object viewed under a compound microscope is numerically equal to the product of the magnifying power of the eyepiece or ocular lens and that of the objective lens—i.e., total magnification = magnifying power of ocular lens × magnifying power of objective lens. A test item can call for calculation of any one term in the equation when figures are given for the other two.

Tests should be designed so that they can be not only easily scored (teachers are busy people) but also completed by students in one class period. Since a test is an instructional as well as an evaluating instrument, pupils should be taught to diagnose their errors and, under teacher guidance, review the subject matter in which their knowledge is deficient. A tally of the errors of the entire class may bring to light an idea which is not well understood, and which should be retaught. In order to make such diagnostic treatment useful, test items should be representative of the aims and content of the text or lesson.

For the Science-Prone. Many of the remarks pertaining to the moderate learner apply also to the rapid learner. However, just as a different approach is recommended for testing the science-shy child, a different approach is recommended for testing the science-prone. It is generally agreed that it is unfair to penalize the science-shy, but we run a danger of penalizing the high-ability pupil if we grade him on a competitive basis in his own selective group—especially where there is homogeneous grouping. We have solved this problem by grading these pupils on the basis of comparable achievement by average pupils in other "normal" classes. Some parents of bright pupils, and also the youngsters themselves, often express apprehension that a class is being "loaded" with a large number of rapid learners. Since the children are college-bound, these parents worry that their children's grades may suffer because of the presence of a large number of other potential high-scoring youngsters in the class. One answer is not to grade these youngsters "on the curve." For the school records, the bright pupils merit high grades.

Does this mean that competition is completely eliminated in a group of bright children? Certainly not! The key person in the pupil's environment, the teacher, can develop an atmosphere which is friendly, but still competitive; he may encourage pupils to think of ways of approaching a concept so that each will vie with the other for a deeper, more probing solution and yet, at the same time, remind pupils that advances in science are often the result of co-operative teamwork.

In some large schools where a number of very bright youngsters

are placed in a special program (including science honors classes), the problem of awarding grades is solved by giving each child a minimum grade of 90% on the assumption that in a "normal" class with less able and less motivated students, he would be able to earn at least this grade. The caliber of his performance in the honors class then determines how many additional points of the remaining ten he will receive.

In smaller schools where special honors classes are impractical, the bright student would no doubt get an excellent grade in a class with "normal" youngsters. However, in evaluating his performance, further recognition may be given in the form of anecdotal records attached to his transcript, which will inform the college entrance committee that he developed certain projects, completed certain advanced readings, developed certain mathematical skills, etc.

Sometimes science-prone students do not appear to study hard enough. At one particular school, a test was devised which encouraged students to study harder, or rather, more thoroughly. The test consisted of two parts; the first being concerned with work just covered, and the second consisting of items which spanned the entire course. Some of these items were based on review; others involved new topics not yet considered in class. The effect of the test was to stimulate the pupil both to review and read ahead, since at all times he could receive credit for "knowing more." "Bonus" questions were given, with extra credit for correct answers; to discourage "guessing," a penalty was given for incorrect answers, but none if these questions were left unanswered. This tended to stimulate many pupils to study harder, due to their natural desire to get good grades and good letters of recommendation.

If previous school records indicate that some of your pupils may be science-prone, your class may be given standard examinations even as early as the beginning of the term. Gifted, or very bright, students may score well above the norm of ninth grade students, thus aiding your identification of them. Two such tests which are useful are: (1) Cooperative General Science Test (Form Q), Revised Series, published by Cooperative Test Service, New York, and (2) Read General Science Test, obtainable from the World Book Company, New York.

Finally, accompanying *You and Science* are the *Harbrace Teaching Tests*, Forms A and B, carefully prepared on the basis of the best practices in test building. What these tests are and how they may be used are the subjects of the next two sections in this chapter.

A TESTING PROGRAM FOR *YOU AND SCIENCE*

We see our part in the teaching process as one of service in furnishing testing devices of such a wide variety that they help the teacher determine whether students understand those concepts of significance in the year's work. These tests can be used, as indicated above, in conjunction with others of the teacher's own devising or choice, to measure achievement over the full scope of the teacher's purposes of instruction.

As we survey the demands of the teaching situation, we see a need for many kinds of tests and test items. For example, we see the need for easily administered, easily scored items which will help the teacher determine whether the student has a mastery of the subject being taught. The plain, unadorned tool for this still seems to be the multiple-choice item. A survey of teaching practice over the country shows this type of item the most common in use—even in the most effective standard tests. We have, therefore, used this type of item in devising two 112-page booklets of teaching tests to accompany *You and Science.*

Increasingly, there is a demand that students develop skill in the interpretation of data in science and, in addition, learn to glean meaning from the material they read. We have, therefore, included a sampling of "tests of interpretation" in these test booklets, but this is not all. In the text, under the "Going Further" section at the end of each chapter and the "On Your Own" section at the end of the book, we have included items which test "laboratory skill" and "reading comprehension." Some of these may be used as optional or extra-credit items if desired.

Students learn the attitudes of the scientist by "doing" science —in short, by investigating. Many opportunities for investigation are suggested in *You and Science* and in this Manual. Such project work, although difficult to grade, is still a vital part of testing a student's knowledge, skill, and attitudes in science.

In each Form of the *Harbrace Teaching Tests*, there are thirty chapter tests, seven unit tests, and four tests of interpretation. Each chapter test contains 20 items, of which 3 or 4 are usually on interpretation; each unit test contains 40 items and each separate test of interpretation contains 20 items concerned with the interpretation of data not found in the text—a total of about 1,000 items in each booklet. From these, teachers may make adequate selection.

The items, of course, are developed mainly around the function of *testing understanding of concepts,* through such devices as:

Direct and simple recall of information
Application of information to concepts
Problem-doing where applicable to the content
Interpretation of data
Reading comprehension
Skill in investigating

The question may be asked as to the reliability of the test items. The Testing Board members* who prepared these items realized that in attempting to test concept-formation in a heterogeneous group it is necessary to develop a kind of crude reliability; that is, a "normal group" should get an average score between 70 and 75 per cent. Hence, there is a range of items from the very easy (testing cheap recall) to the very difficult (expensive recall or problem-doing items). Rough trials in several schools verified the expectation of the score distribution.

It is expected to procure reports from a variety of schools to determine whether this crude reliability applies generally. Of course, the tests have face validity; that is, the concepts and the information tested are distributed in accordance with the emphasis placed on them in the text *You and Science.*

The tests made available in the total testing program—test booklets, end-of-chapter tests of various kinds in the text, tests to determine skills in doing research and investigations—are designed to help you in your work of appraisal. The postcards bound in this Teacher's Manual are for your convenience in corresponding with the editors or the Testing Board should you have any questions or suggestions for the program meant to serve you.

USING TESTING MATERIALS

There are several testing steps which can be followed in using the total program of text and tests provided for a year's work with *You and Science* as the classroom text.

1. Before each unit is begun, a teacher should have his pupils make a self-appraisal by taking the unit inventory test printed at the beginning of each unit in the text. This is in the nature of a pre-test. Pupils are to understand that they will not be graded, but that the questions are merely a way for them and their teacher to find out how much they know about a general area in science. For the teacher, this has value in diagnosing achievement in earlier work in science, in planning the topics that should be stressed, and in allotting the amount of time for study of the unit.

2. In one school we know, the two sections, "Tool Words" and "Test Yourself," are used as a pre-test before the chapter is actually studied. These sections will be found under "Looking Back" at the end of each chapter.

Inasmuch as pupils will take this test again (in self-appraisal

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after studying the chapter), they will be able to compare their gain in knowledge. The unit inventories may be used in the same way.

3. After study of each chapter, a secure test is available in the two forms of test booklets for *You and Science* as described in the preceding section. To maintain security, the teacher keeps the test booklets, handing them out only when the test is given. The two forms may be used in alternate years, in alternate rows in the classroom, or in different classes on the same day. The teacher generally records the scores on these chapter tests, often according to a system of grading that takes into account varying abilities.

4. For each unit the teacher will have three or more scores, one for each chapter. The unit test in the test booklet used adds one additional score. In a sense, the unit test score will confirm the separate scores. A total grade for the unit may then be an aggregate of chapter tests (50 per cent of the total unit score) and the unit test (50 per cent of the total unit score). This does not penalize excessively either the slow learner, who needs time to get basic concepts, or the rapid learner, who gets these principles quickly. In any event, this prorating shows some reliability in practice in the school for which it is being reported.

5. Many schools will give a semester test. This is then considered to be 25 per cent of the total semester score, the unit scores making up the other 75 per cent.

Evaluation. Study of scores made on these tests shows that, in general, there is a high correlation between them and I.Q. and standard reading and arithmetic test scores. Hence students' low scores, medium scores, and high scores on the science tests should relate to their I.Q. and reading and arithmetic scores. If there is not a fairly good relationship, then it might be valuable to look into certain factors such as how much time the pupil spends in study and his orientation toward science or toward the school.

The purpose of the test booklets is to supplement further the favorite essay and short-answer tests each teacher prepares in expression of his own special objectives of teaching.

CHAPTER 6: USING OTHER TEACHING RESOURCES

Throughout Part B of this Manual, there are many suggestions for doing laboratory work, using the library for added information by way of research reports, planning for field trips, using films and filmstrips, collecting specimens, making posters, preparing

bulletin board exhibits, and many other activities to enrich and extend the pupils' knowledge of science. For the most part, these are self-explanatory. However, it may be helpful to suggest a few ways to make the most of these resource activities.

USING THE CLASSROOM AS A CENTER OF INVESTIGATION

Many schools, unfortunately, do not have laboratory facilities for junior high school science. And yet we know today that experiences in science through investigation lead to sound and more thorough learning. What can be done to foster an atmosphere of investigation in the classroom?

Almost the first prerequisite is a posture toward problems—whether implied or stated—and the information which is deliberated in class. Where desirable, possible, and practicable, three questions might be asked of students: (1) How do you know what you know? (or—Have you evidence for your statement?); (2) How well do you know what you know? (or—How much evidence do you have?); (3) Is your statement really accurate? (or—Have you tried to defeat your statement?)

In a classroom that has an atmosphere of calm investigation, an atmosphere of science may be developed. This involves a personal attitude toward discovery, which means that an atmosphere of the science laboratory needs to be developed—even where equipment is at a minimum and the budget sparse. Here the ingenuity of the teacher and the class are paramount. Some teachers have adopted the following procedures and devices:

1. They have co-operatively planned a window sill conservatory. One procedure is to form a student committee to care for plants. The "conservatory" could furnish cuttings and plants for studies of photosynthesis, plant nutrition generally, and plant behavior (e.g., phototropism).

2. Where space is available in some parts of the room, a large table might be brought in and set aside for demonstration or committee work. Specific equipment needed for key activities in each chapter is listed in this Manual at the beginning of each unit. General equipment should include:

a. An alcohol spirit lamp (for heat)
b. A pitcher and bucket (for water)
c. Baby-food bottles (as containers)
d. Tablespoons with handles wrapped in cloth (used when heating chemicals)
e. Wall board or asbestos sheeting to protect the tables
f. Chemicals—only a few will be needed
g. Equipment and apparatus which may be obtained with relative ease—magnets, batteries, wire, bulbs, sockets, etc.

3. An exhibit area might be developed. For example, charts might be exhibited on the bulletin board and projects displayed on the large table or window sill or any convenient part of the room.

USING THE WORKBOOK

A workbook and laboratory guide can be a valuable resource in teaching general science. If you have the use of a laboratory—even occasionally—you can help students develop laboratory skills. If you do not have the use of a laboratory, you can encourage ingenuity in developing laboratory procedures in the classroom, as suggested above. The laboratory workbook to accompany *You and Science,* New Edition, is *Experiences in Science,* Third Edition.

The workbook can serve several purposes if properly used. If it becomes your sole approach, its effectiveness will soon wear thin, for the students will eventually become bored with a procedure that is routinized around a single method. However, it can give special emphasis to certain principles of scientific procedure. It can provide special activities, experiments, and demonstrations to give the students direct experience with testing the ideas mentioned in their texts. It can provide a fairly easy means of recording answers to questions and records of experiments. It can serve as a review of the pupil's own thinking on the questions being studied.

With what type of classes can this workbook be used? And how can it best be used in individual classes throughout the year? Among the activities in each chapter are experiences planned for students of all kinds—simple experiences for the slower students, experiences of average difficulty for the so-called average students, and more complex experiences for the brighter students. Briefly, this workbook can be used in the following ways:

1. As a Guide, Giving Directions for Laboratory Work. Students are given help in setting up experiments or demonstrations that illustrate some principle in science, whether biology, chemistry, or physics. For example, there are step-by-step directions for setting up experiments with the chemicals around us, and to illustrate laws of flotation, machines, electricity, reproduction, light and sound, and so on.

Again, students are guided in their observations as they perform the experiments. Questions help the students to make accurate observations of what they are expected to see. This procedure of setting up an experiment by providing careful directions and of planning for careful observation is applied to such varied topics as the testing of green leaves for starch, the composition of different kinds of coal, electrolysis of water, parallel and series circuits, comparison of soft and hard water, digestion in the mouth, and nutrient tests, among others.

2. As a Guide to Investigation. The workbook contains sections where students are urged to plan their own experiments. At other times they are given data in an experiment and then are asked to evaluate a series of generalizations based on the data given. In class, there is opportunity for the teacher to help students improve their ability to interpret reports of scientific achievements. Although all students need practice in these skills, the slow readers urgently need help in discriminating between fact and fiction.

With average classes, time may be spent on pointing up the methods of scientists. The type of activities found in this workbook illustrate different methods used by scientists: their methods of observation, experimental planning, or approach to the interpretation of facts already established.

3. As an Extension of the Day's Work in the Classroom. Many students can answer the questions in the workbook at home if they are expected to use it as a study guide (along with the textbook). There are activities which guide them toward preparing summary statements on every concept studied.

The self-tests at the end of each chapter may be taken at home by students, and the students may learn to graph their progress from week to week.

4. As a Guide for Slow Learners. The workbook focuses on those facts of science that directly relate to the students' daily life. This focus is essential for the slower student, who needs help in organizing his studying. He will find especially useful the short directions with illustrations which precede the activities. The questions in the workbook should also stimulate selective reading of the textbook. The slow learner will be helped to focus his learning by filling in the summary charts provided in the workbook.

5. As a Guide for Possible Term Projects. Many of the activities raise problems for further study. These involve research through readings. The activities attempt to stimulate students to try out ideas. Some of the suggested activities are set up so that several students may engage co-operatively in their solution.

Many of the activities serve as a springboard for more advanced study. The first steps in techniques are practiced when students do many of these activities. The students can bring these techniques to more advanced problems for group work or individual projects and small "original" experiments. Thus students may plan to exhibit their projects at science fairs.

6. As a Guide to Stimulate Hobby Interests in Science. Many of the activities in weather forecasting, astronomy, electricity, chemistry, biology, and photography provide the first steps for further study and development of hobby interests.

7. As a Guide for Planning Field Trips. Small groups of students may be led into exploration of nearby parks, open areas, streams, and lakes in search of materials to examine under the microscope. Other groups may plan studies in conservation in the neighborhood; still other groups may want to study planets and stars. A few preliminary supervised field trips are advisable to give students help in learning how to locate materials. If it is desirable, groups of students may plan trips on Saturdays.

8. As a Guide for Club Activities. Class activities in using the microscope, in soil testing, conservation studies, photography, making exhibits which "light up" when a circuit is completed, or setting up photoelectric cells may serve as extensions of work begun in the classroom. After-school hours can be filled with pleasurable activities which extend from classroom work.

9. As an Open-Book Test. Used along with the textbook, many sections of each workbook chapter furnish specific short questions in the form of charts or summaries. These require application of understandings derived from reading the textbook or from discussions in class. These questions may be used to discover how students study, how they locate information in the text, and how they assimilate the facts they have read in order to apply them toward the solution of specific problems. The section "Testing Yourself" may frequently be used in this way.

Thus the workbook can function as a personal guide to students to stimulate their search for information; to help them solve their problems, personal and otherwise; to help them to understand themselves as well as others; and to give meaning to the phenomena of the world around them. The workbook furnishes experience in search of meaning.

USING FILMS AND FILMSTRIPS

In general, the purpose of films and filmstrips is to use visualization as an aid in leading pupils toward concept formation. Although films and filmstrips can picture for the student a laboratory experience, they can never replace it entirely; viewing utilizes only one of the senses through which we gain knowledge and impressions, while handling of laboratory equipment in an experiment utilizes several senses.

There are many ways to use films and filmstrips and thus bring field and laboratory into the classroom. A common approach to the use of audio-visual aids has four steps:

1. *Preview to determine content.* If a booklet accompanies the film or filmstrip, you may often obtain a good idea of the film's content and approach without a preview being necessary.

This is helpful if a projector is not available at all times or if the film, being a popular one, is closely scheduled.

2. *Advance planning with the class.* Questions on the topic of the film can be explored by teacher and class through discussion; sometimes the approach can be tied in with an assigned or volunteer pupil report or a committee research project. Whatever the approach, it is always useful to prepare the pupils in advance of the film showing.

3. *Introducing and projecting the film.* One method is to use a demonstration or other activity as a motivation of the topic, either a day before or, if there is time, immediately before the showing.

Some films and filmstrips are accompanied by lesson plans suggesting specific activities. This is true of the *Teacher's Lesson Plans for Harbrace Filmstrips.* These eight filmstrips are designed to accompany *You and Science,* the third book in the *Science for Better Living* Program, with one strip to accompany each unit in the text. For further information, write to the publisher, Harcourt, Brace and Company.

If a filmstrip has captions, various pupils may be asked to read these aloud; after several frames you may want to stop the projector in order to develop the ideas through discussion. Depending on the filmstrip, you may feel that each frame should be discussed, notes taken, pupil demonstrations presented to supplement the sequences, and finally, a summary written by the entire class. Pupils should be permitted to request repetition of a given frame.

4. *Follow-up.* After the showing, pupils should determine which of their advance questions were answered and what new questions were raised, and discuss ways of further investigation to discover fuller answers. Again, additional class activities can extend the concepts brought out by the film showing.

You will, of course, be able to invent many approaches to enable pupils to see more clearly how a film or filmstrip tells a story, develops a theme, or builds or extends a concept. In this way a new visual dimension extends and intensifies the concepts developed in the text. Part B of this Manual suggests many films and filmstrips and ways of using them in specific chapters for specific concepts. Many of them can be used to introduce a unit or chapter, to review, to develop concepts, or to test understanding. For the science-shy, words and images reinforce each other, making concepts easier to learn. For the science-prone, insightful imagery and further work are stimulated. For the moderate learner, both results are possible.

USING TV AS A RESOURCE IN TEACHING SCIENCE

Often your TV guide or your newspaper will list science programs of considerable interest. Reports may be made in class,

or individual students stimulated to do projects. For instance, the following listing indicates the science programs shown in one viewing area during the week of April 25 to May 1, 1959.

Saturday, April 25

8:30 a.m. Ch. 5 *Design for Learning* "Satellites, Schools, and Survival." Dr. Arnold Pike.

11:30 a.m. Ch. 4 *Mr. Wizard* "Siphons." Mr. Wizard (Don Herbert) explains the workings of siphons to Doug. He shows how they need water and air to work and helps him build a siphon that hiccups.

Sunday, April 26

3:30 p.m. Ch. 2 *Tales of the Universe* "Planets Are Like Seeds." Dr. Heinz Haber and his guest Dr. Pier Maria Pasinetti discuss the planetary system.

4:00 p.m. Ch. 4 *Next Hundred Years* "Mutations, the Raw Materials of Evolution." Today's host is Dr. Norman Horowitz, Caltech biology professor.

5:00 p.m. Ch. 11 *Men, Medicine and Space* This one-hour live remote from Los Angeles International Airport is presented in conjunction with the Aero Medical Association to test the reaction of human beings subjected to the unknown pressures of outer space.

Taking part in the demonstration will be a team of doctors who will keep in constant contact with test pilots cruising above the earth's atmosphere. One of the test pilots will be Scott Crossfield, who recently completed the first captive test flight of the X-15 rocket plane. Another test pilot, Al White, will be placed in a pressure chamber simulating the effects of high altitude and low temperature. A TV camera will follow him into the chamber, during which time a physician will keep a continuous check on White's physical reactions.

6:30 p.m. Ch. 2 *Twentieth Century* "Toward the Unexplored: the Flight of the X-2." In 1956, the Bell X-2, a rocket-powered experimental aircraft, climbed higher than man had ever gone before (126,000 feet) and reached a speed which man has not surpassed (2,178 miles per hour)—and crashed to earth. Air Force films show part of this final flight of the X-2 from the Air Force Flight Test Center at Edwards Air Force Base in California's Mojave Desert. Walter Cronkite narrates.

Monday, April 27

6:30 a.m. Ch. 4 *Continental Classroom* "Nuclear Reactions," Part 2. Dr. Harvey E. White.

8:00 p.m. Ch. 13 *Adventure Tomorrow* "Countdown at Santa Susana." Dr. Klein goes to a testing center located only thirty-five miles from Los Angeles. Included are shots of an Atlas engine being tested and the operation of the blockhouse. Dr. Martin Klein is host.

Tuesday, April 28

6:30 a.m. Ch. 4 *Continental Classroom* "Induced Radioactivity." Dr. Harvey E. White.

Wednesday, April 29
6:30 a.m. Ch. 4 *Continental Classroom* "Experiment on Induced Radioactivity." Dr. Harvey E. White.

Thursday, April 30
6:30 a.m. Ch. 4 *Continental Classroom* "Neutron Reactions." Dr. Harvey E. White.

Friday, May 1
6:30 a.m. Ch. 4 *Continental Classroom* "Electron Accelerators." Guest lecturer is Dr. D. W. Kerst, Physicist from San Diego, Calif.

USING LIBRARY RESOURCES

Throughout Part B, listings are given of books useful to teachers and students. Throughout the text, books and pamphlets are given as references. But it should not be assumed that youngsters know how to use the library. A number of teachers conduct a "field trip" to the library where the librarian gives the class a lesson in the use of the catalogues, magazines, and clipping files.

A good start for a full science library begins with the references in the textbook; slowly, as funds become available, basic references may be added. These can be obtained by examining the reviews in *Science*, the *Scientific American*, etc. Also it is useful to examine the catalogues of a university or college library.

USING COMMUNITY RESOURCES

In whatever community the school is situated, community resources may be used in the teaching of science. A farm or a health center is a center for biological study; water works, meteorological stations and airports are centers of "applied" science; steel plants, bakeries, paper mills, and telephone exchanges are centers of scientific activity of various kinds. Attendance at a science fair—local, county, or national—is a rewarding experience in stimulating pupil interest and progress.

But trips—like other lessons—require careful planning. Before the trip students need to discuss what they might see; after the trip they need to discuss what they have seen and learned.

A committee of students might plan the trip. A letter or visit might set up the trip; a letter saying "Thanks" should always follow up the trip. Or if the visit is written up, send your hosts a copy of the newsletter or clipping from the school paper. These courtesies are appreciated and often open the door to greater cooperation between the school and industrial or scientific resources in the community.

PART B

TEACHING THE UNITS

PART B
Teaching the Units

UNIT 1 *Man—As Scientist*

GENERAL THEME: *Man uses his brain, his capacity for learning, and his ability to apply science and the ways of the scientist in attempting to master himself and his surroundings.*

As an introduction to this year's work, the pupil looks into the way he learns and the way scientists learn. He sees how scientists work and appreciates the need for accuracy by scientists in industry, research, medicine, and other important fields (text pages 13-32). He learns that he has certain special traits (flexible thumb, voice, large brain, etc.) that enable him to survive and master his environment as no other living thing can (pages 33-40). Then he examines his behavior patterns, those that are unlearned (reflex acts) and those that are learned (habits). He sees how inborn behavior can be changed (pages 42-43) and how good habits are formed and poor ones broken (pages 43-45). Learning how to study efficiently (pages 46-48) is a step forward in the adaptation to another environment (a new class or school).

The Unit Inventory. Prior to starting a study of the unit, it is recommended that students answer the questions in the unit inventory on text page 12 in order to take stock of their general scientific background or of information acquired in earlier courses. Of course no grade is to be assigned, but a discussion of the results may reveal the concepts or areas of information that need the greatest stress. In this way, the teacher is aided in planning the most efficient allotment of time and in getting a preliminary estimate of the abilities of the class.

PLANNING AHEAD

Throughout this Manual many suggestions are given for various activities from which you may wish to make a selection as you develop the concepts and central ideas of the text. You may wish to use films; these must be ordered in sufficient time for them to be available and possibly previewed before showing. You may wish to take field trips or put on special programs; these need to be arranged in advance.

It is a good idea to look through the activities suggested for a unit before you begin teaching it. For your convenience, this Manual lists at the beginning of each unit those materials and projects for which you need to allow extra time or make special plans. The listing follows the order in which the items would be needed if you follow the chapter-by-chapter sequence. A more complete list of films, filmstrips, and books—arranged by topics—appears beginning on Manual page 202.

FILMS AND FILMSTRIPS

f = film	fs = filmstrip
c = color	si = silent film

Chapter 1

1. *The Scientist—His Way, Your Way* (fs,c), Harbrace, 1957.

Chapter 2

1. *Behavior in Animals and Plants* (f,c), Coronet, 1957.
2. *The Nervous System* (f), EBF, 1937.
3. *Problem-Solving in Infants* (f,si), Int. Film Bureau, 1942.
4. *Problem-Solving in Monkeys* (f,si), Int. Film Bureau, 1941.

LABORATORY EQUIPMENT TO BE ASSEMBLED

Chapter 1

2 beakers (100 ml.); 1 graduated cylinder (100 ml.), talcum, corn starch, sodium bicarbonate, sugar (sucrose), table salt (sodium chloride), iodine solution, culture of fruit flies, food medium (banana), 3 jars, gauze, large battery jar, cord

Chapter 2

photographs of athletes, scientists, etc., yardstick, calf or sheep brain, cotton, glass plate (with taped edges), radio or record player, white rat or hamster, animal maze or drawings of animal maze

FIELD TRIPS TO BE ARRANGED

Visit to industrial or medical research laboratory.

CHAPTER 1: WAYS OF THE SCIENTIST
(text pages 13-32)

• CONCEPTS AND KEY ACTIVITIES

1. *Scientists use various methods or ways in getting at the evidence; there is no one method.*

2. *Controlled experiments reflect the need for accuracy in solving problems.*

3. *There are many science fields which offer vocational possibilities.*

We suggest that just as there is no one exclusive scientific method, so there is no one way to approach the teaching of general science. Teaching is a personal activity which reflects the creative personality of the teacher. You may wish to modify or adapt our own favorite ways to approach a given concept. In the pages that follow, you will find ways other teachers have introduced and developed certain concepts. The method you find most successful often may be your own personal invention built on the experiences of others.

One way to stimulate interest in your approach to the topic of scientific methods is to involve the class in a simple experiment. Fill two identical glass containers—one with small pieces of gravel and the other with stones or large pieces of gravel. Now ask which jar contains the greater amount of air space between the pieces of rock. Ask whether the pupils can suggest (design) an experiment to find out. (This involves pouring water into the jars.) Some students may have started as a hypothesis that there is more space between the larger stones than between the smaller pieces of gravel. After water has been poured in each jar, it can be measured, and the pupils can draw a very simple conclusion from a simple observation. Repeat the experiment several times. Discussion can reveal that simple measurement is one basis for the accuracy of an observation. Have pupils comment on the way they went about arriving at their conclusions.

For the Bulletin Board. A committee can collect and post clippings of recent scientific discoveries (including photographs of the scientists making them). List the specific instruments or other tools used in observations.

Analyzing a Procedure. Have several glass jars filled with white powders of different substances (for example, talcum, starch, bicarbonate of soda, sugar, and salt). Ask the class to

determine which jar contains the starch. If no pupil suggests the use of iodine solution in testing samples from each jar, demonstrate that a blue-black color results from the reaction between iodine and starch. Ask a student to explain how he would go about the search for starch. Ask him to analyze the procedure under these headings:

1. What was the problem?
2. What equipment, what apparatus, was used?
3. What was the "working idea?" (The hypothesis.)
4. What was the method? (The "try-it-and-see" approach.)
5. What was the conclusion?

Emphasize that this is not *the* scientific method, but only *one* method, sometimes called the "trial and error" approach.

Field Trip. A visit to a nearby industrial or medical research laboratory will help kindle interest in the ways of the scientist. Encourage pupils to ask questions relating to the different methods scientists use. What tools do they use?

Reading About "Chance" Discoveries. Text pages 29-30 can be read and the work of Perkin discussed. Ask why it is important for scientists to build on the experiences of others. Ask for a pupil report on Fleming's work (discovery of penicillin).

A Collection of Science Journals. Pupils may be able to bring in copies of *Science News Letter*, *Scientific American*, and *Science World* (see the local library). If a local physician can lend you copies of his journals, you can build a temporary display of science works which are published (and thus communicated to others). The industrial scientist, the research scientist, and others communicate their findings at scientific meetings and in journals.

Construction and Study of a Chart. The chart on text page 25, summarizing the ways of the scientist, can be discussed. After pupils have contributed some examples of the ways scientists work, have them enlarge the chart and include some of their examples on it. They may be able to make an attractive pictorial display chart.

Filmstrip. The Harbrace filmstrip *The Scientist—His Way, Your Way* can be used to show the scientific activity of Fleming and others. A pupil report can help introduce this filmstrip.

Setting up an Exhibit. Pupils will appreciate the opportunity to browse among various books, booklets, and articles on scientific careers. Committees can help you organize bulletin board material and write for booklets available from government and industrial sources. An excellent source of addresses is *Keys to Careers* (5th edition). Also, see text pages 31-32.

HELPING THE SLOW LEARNER

Assign as a homework or class project the control experiment on text page 22 (bread mold). Have the pupil make simple drawings

of his observations. (*Note:* an antimold chemical such as sodium propionate is often added to bread by baking companies.)

Help pupils set up a controlled experiment to show that fruit flies come from other fruit flies. How can you show that they do not come directly from fruit such as bananas? (Control jars will include a solid-covered jar and a gauze-covered jar. The third jar, experimental, is left open.) Look for the larval or maggot stage about eight days after the mating--room temperature of 68° F. To speed up results, place all three jars in a large battery jar, introduce fruit flies into the larger container, and then cover with cheesecloth.

HELPING THE RAPID LEARNER

Pupils who show high-level ability in science may be interested in a possible scientific career. Try to arrange for visits from persons in scientific fields who are graduates of the school. If there is a guidance counselor, perhaps he can give a special talk to these pupils on scholarship opportunities, summer programs for science students, or various award programs (National Science Fair, National Science Foundation, Science Achievement Awards for Students, Westinghouse Scholarships for the Science Talent Search, etc.).

There are a number of awards, fellowships, and other programs for teachers of general science. Write to the National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington 6, D.C., for *Encouraging Future Scientists: Keys to Careers*.

The *Harvard Case Histories in Experimental Science* will interest rapid learners. Suggest "Pasteur's and Tyndall's Study of Spontaneous Generation" (Vol. 2, pages 489-539) for a first-hand account of the work of these men. A translation of excerpts of Redi's "Experiments on the Generation of Insects" is included here.

CHAPTER 2: WAYS OF LEARNING
(text pages 33-51)

• CONCEPTS AND KEY ACTIVITIES

1. *Our nervous system helps us in the way we do things.*

2. *Automatic acts are either inborn or formed after birth.*

Show pictures of people in sports, aviation, science, etc. Ask how these people manage to do their job well. What controls the

wonderful co-ordination of flexible thumb and voice? Compare with lower animals. Then lead into a consideration of sense organs, nerves, and brain.

Demonstrating Activities of Our Sense Organs. You may wish to have pupils improvise ways of illustrating use of our organs of sight, smell, taste, hearing, and touch. Research may be conducted in such references as *Your Biology* or *Your Health and Safety.* For example, show the class a yardstick and ask what they saw. Then, ask what a three-year-old would indicate that he saw. Slam the yardstick, have pupils smell and touch the object. Discuss the loss of function (temporary or permanent) in some of our sense organs. How does a cold affect our senses?

Demonstrating Structure of the Brain. Ask pupils to get a brain of a calf or sheep from a butcher. Identify the main parts (cerebrum, cerebellum, and medulla) and ask for a review of their functions (text pages 39-40 may be used). The rapid learner may report on a comparison of brains in different animal groups.

Demonstrating Reflex Actions. Ask pupils to suggest things they can do perfectly, without learning, from the day they were born (heartbeat, breathing, etc.). Pupils can demonstrate reflex action by throwing a tuft of cotton at the face of another pupil protected by a glass plate. Ask whether he directed his eyelids to blink.

Students, working in pairs, can each cover one eye (for about one minute). When the cover is removed have one student in the pair observe what happens to the size of his partner's pupil when light hits it. Did he control the action consciously? What happens when a person touches a hot object for a moment? Use the diagram of a reflex arc (text page 41) or draw an enlarged one in colors on the board to help pupils explain the actions. Ask what nerve passageways are involved when you say "Ouch!" Stress that reflex actions may be surrounded by *learned* actions (such as ability to express one's feelings).

Demonstrating Habit Formation. Ask the class to copy a sentence you will dictate, telling them not to cross their *t*'s or dot their *i*'s. Then lead into discussion of habit formation.

For the Bulletin Board. List various safety practices which depend on good habit formation. Pupils can list poor safety habits also. Include bicycle regulations, health regulations, etc.

Demonstrating Conditioning. A simple way to introduce conditioning is to ask pupils to write the numeral 1 each time you give the command "Write." As you say "Write," rap the table with a ruler. After ten or fifteen times, continue rapping but omit saying "Write." Most pupils will continue to write the number 1 in response to the rapping (the substitute stimulus).

HELPING THE SLOW LEARNER

If any youngster raises goldfish or guppies, suggest he try to train or condition them by flashing a light or tapping one corner of the tank every time he feeds them. Perhaps he can bring his pets to class and perform the demonstration and answer questions about their training. Allowing the slow (or science-shy) child to make a contribution of this nature will help satisfy his desire to gain status with his classmates.

Encourage him to make models of nerve cells and the human brain, using modeling clay. See text pages 38-39 for diagrams. Various colored threads can connect specific parts to pins sticking into an appropriate caption.

3. *Good habits of reading and study result in faster, better learning.*

Start discussion of study habits by using the activity on text page 50 wherein students memorize words from three different lists. Let pupils develop the conclusion that problems can be solved faster when they know the problem and the meaningfulness of the methods and materials used. Students can tell which of their study methods they consider good.

Demonstrating the Effect of Distractions on Learning. Have the class memorize the first stanza of a poem under these conditions: Play a recording of loud music or play a radio in the room. Have the pupils time themselves. Repeat for the second stanza but turn off the radio or record player. Which situation took longer? Ask different pupils to describe the conditions under which they study at home. Have the class draw up a list of suggested study procedures.

HELPING THE SLOW LEARNER

Improving the study habits of the slow learner often results from stimulating his desire to make discoveries. He recognizes the need for improving his reading ability. If he is engaged in making a three-dimensional clay model of the brain, he must visualize dimensions as in the description and diagram on text page 39. Consequently, his reading of the paragraphs is based on a *desire* to gain information he will use toward a definite goal.

Ask the slow learner to state the main idea of a selected paragraph in one short sentence. You may find various techniques helpful. For instance, draw up a key question for each paragraph, and have him refer to it *after* writing a summary sentence. If he has difficulty, allow him to use the key question as a guide for

composing his summary sentence. Encourage him to summarize without having to depend on your questions, eventually.

HELPING THE RAPID LEARNER

The rapid learner may want to discover experimentally whether rats or hamsters learn equally well under different conditions. Using wood and window screening, he can construct a rat maze from patterns of his own designing or from consulting a college psychology text. (See also page 133 of *A Sourcebook for the Biological Sciences*.) Wood channels six inches high and topped with screening are nailed to the base of the maze. The pupil should select a hungry white rat or hamster for training and put it through the maze several times. When it is successful in getting to the end, reward it by giving it food and petting it. Thus the animal comes to associate food and stroking with completion of a task. Keep a record from day to day (or several times a day) as the hungry animal is put through the maze. Compare the performance of younger with older rats. Class discussion can later follow along such lines as: Does learning go on faster when reward rather than punishment accompanies the task? Does age affect learning? Pupils can cite examples from their own activities.

Students may wish to work as a committee to compare the rate of learning in rats which have a thiamine deficiency with the rate in normal controls. Let students do their own research and planning. Perhaps they may want to study the effect of caffeine on speed of learning.

The high-level-ability student can help you prepare for class showing of a film. Have him (or a committee) preview such films as *Behavior in Animals and Plants*, *The Nervous System*, *Problem-Solving in Monkeys*, and *Problem-Solving in Infants*. For each film he should draw up a list of key questions for class discussion. Suggest that the film be stopped during the run for comments and mid-summary. A prepared question may be asked at this time and the answer revealed during the showing of the second part of the film.

Rapid learners appreciate the confidence shown in them when teachers allow them to make suggestions and take part in class planning and leadership.

SUMMARY AND USE OF TESTS

Learning the ways scientists work is most meaningful when youngsters practice approaches to a problem in classroom and laboratory. This is far better than having them memorize stereotyped "steps" in scientific method. By participating in science

activities (which includes *thinking*) the pupil learns the meaning of controls, and how to distinguish between fact, opinion, superstition, hypothesis, theory, and conclusion.

You may wish to use the *Harbrace Teaching Tests* to accompany *You and Science*, Forms A and B. All the tests in the booklets are objective-type and are perforated for ease of removal. Each booklet contains chapter and unit tests, as well as tests of interpretation. The items in each test are so balanced that a pupil score on one test in Form A will be similar to the pupil score on a similar test in Form B. The answer spaces are at the right for ease in key-scoring. A key to these tests is at the end of this Manual.

BIBLIOGRAPHY FOR STUDENTS

1. Clemensen, J. W., and others, *Your Health and Safety*, 4th edition, Harcourt, Brace, 1957.
2. Conant, J. B., and others, *Harvard Case Histories in Experimental Science*, 2 Vols., Harvard University Press, 1957.
3. Pollack, P., *Careers and Opportunities in Science: A Survey of All Fields*, Dutton, 1954.
4. Pollack, P., *Your Career in Physics*, Dutton, 1955.
5. Representative copies of *Science News Letter*, *Scientific American*, *Scientific Monthly*.
6. Smith, E. T., and L. Lisonbee, *Your Biology*, Harcourt, Brace, 1958. Pages 206-21 include some suggestions for activities and projects on the nervous system.

BIBLIOGRAPHY FOR TEACHERS

1. Brandwein, P. F., F. G. Watson, and P. E. Blackwood, *Teaching High School Science: A Book of Methods*, Harcourt, Brace, 1958. See the first section, on the special climate of the classroom.
2. *Encouraging Future Scientists: Keys to Careers*, Natl. Science Teachers Assoc. Excellent for teacher and pupil. Contains many pertinent items, including science-improvement programs for *teachers*.
3. Morholt, E., P. F. Brandwein, and A. Joseph, *A Sourcebook for the Biological Sciences*, Harcourt, Brace, 1958.

UNIT 2

Lengthening Man's Life

GENERAL THEME: *Man, by his increasing knowledge of nutrition and medicine, has lengthened his life span.*

As we learn more about how the body uses its food, what are the causes of disease, and how diseases can be treated, we can improve the health of individuals and of the nation as a whole. In order better to understand himself, the pupil is given the opportunity to examine his body functions. He learns about the smallest units of his body—the cells, what they consist of, and how they oxidize food and act as body builders (text pages 55-60). Then he discovers the different kinds of foods the body needs, the calories and vitamins they provide, and what makes up a balanced diet (pages 61-78). The pupil then learns what his blood consists of, how it carries food to every cell in every organ of his body, and how his body's wastes are disposed of (pages 79-97).

The pupil already knows that microbes cause certain diseases. He is given opportunity to learn what defenses his body puts up against disease and how science has helped by developing vaccination, inoculation, and medicines (text pages 100-15). Finally, he sees how his community helps fight disease by passing sanitation laws as well as laws to safeguard food, milk, and water (pages 118-27). Man's life is also lengthened by prevention of accidents at home, on the street or playground, and at school (pages 129-31).

The Unit Inventory. Before commencing study of this unit, you will find it helpful to have the pupils test themselves on what they know of the general theme of lengthening man's life (text page 52). On the basis of their answers and subsequent discussion, you will better be able to stress the points that need the greatest elaboration. And you will also have a basis for allotment of time to specific topics and supporting activities.

PLANNING AHEAD

So that you may plan in advance for a particular film or filmstrip, assemble needed laboratory equipment, or arrange a field trip, the following items are listed in the order in which they are mentioned in this unit. A more complete list of films and filmstrips, arranged by topics, appears on Manual page 202. Additional reading references will be found following the chapters and also beginning on page 211.

FILMS AND FILMSTRIPS

f = film   fs = filmstrip
c = color   si = silent film

Chapter 3

1. *Cell—The Structural Unit of Life* (f,c), Coronet, 1949.
2. *Foods and Nutrition* (f), EBF, 1940.
3. *What Makes Us Grow* (f), Natl. Film Board of Canada, 1944.

Chapter 4

1. *Circulation* (f), Am. Heart Assoc., free.
2. *Circulation* (f), UWF, 1950.
3. *Digestion of Foods* (f), EBF, 1938.
4. *Heart—How It Works* (f), McGraw.
5. *Hemo the Magnificent* (f,c), Bell Telephone, 1957, free loan.
6. *Your Life Stream* (fs,c), Harbrace, 1957.

Chapter 5

1. *Antibiotics* (f,c), EBF.
2. *The Cancer Challenge to Youth* (fs,c), Am. Cancer Soc., 1959, free from local ACS Unit or Division office.
3. *From One Cell* (f,c), Am. Cancer Soc., 1950.
4. *Goodby, Mr. Germ* (f), Natl. Tuberculosis Assoc., 1940, free.
5. *Health Heroes* (fs), Metropolitan Life Insurance, free.
6. *Man's Greatest Friend* (f), TFC, 1938.
7. *The Traitor Within* (f,c), Am. Cancer Soc., 1947, free loan.
8. *What Is Disease?* (f,c), Inst. of Inter-Am. Affairs, 1945.
9. *The Winged Scourge* (f,c), Inst. of Inter-Am. Affairs, 1943.

Chapter 6

1. *City Water Supply* (f), EBF, 1941.
2. *Clean Waters* (f,c), General Electric, 1946, free.
3. *Community Health and You* (f,c), McGraw, 1955.
4. *Making Water Safe to Drink* (fs), Popular Science, 1953.
5. *Water Supply* (fs), Academy, 1947.

LABORATORY EQUIPMENT TO BE ASSEMBLED

Chapter 3

compound microscopes (100×, 430×), iodine solution, toothpicks, glass slides, cover slips, prepared slides of various tissues, 2" × 2" slide projector, screen, color slides of various tissues, Plasticine (or oil-base modeling clay), marshmallow, tongs, empty one-gallon pickle or mayonnaise jar, pictures of basal metabolism apparatus, food charts (obtain free from General Mills, Minneapolis, Minnesota)

Chapter 4

fresh beef lungs with attached windpipe, bell jar, bromothymol blue, 4 beakers (50 cc.), straws, goldfish, glass slides, microscope, Petri dish, cotton, fresh beef heart, 18" piece of red rubber tubing, 18" piece of black rubber tubing, large chart of general body circulation, fresh beef kidney, funnel, filter paper, red vegetable dye, sulfur

Chapter 5

life-expectancy charts (from any life insurance company), standard nutrient agar, (Difco, 4 oz.), 10 Petri dishes, sauerkraut juice, yogurt, pipettes or medicine droppers, glass slides, cover slips, microscope

Chapter 6

milk bottle caps (with date of pasteurization), labels from packaged food products, alum (potassium aluminum sulfate), glass funnel, sand, earth, mosquito larvae

FIELD TRIPS

Visit to general medical laboratory; visit to college or medical bacteriological laboratory; visit to school nurse or local physician or arrange to have them come as guest speakers; visits to local creamery, bottling plant, milking barn, or slaughterhouse; board of health laboratories or clinic; school cafeteria; a water-treatment plant.

CHAPTER 3: YOUR CELLS AND THEIR NEEDS
(text pages 54-78)

• CONCEPTS AND KEY ACTIVITIES

1. *The various body cells produce many products necessary for life*.

This broad concept may be introduced with microscopes, a film, or the figures on text page 57. If one or more microscopes are available, pupils will be able to make first-hand observations of the differences between many cell types. With regard to cheek cells, point out that many are half dead and thus easily removed. Regulate the light on the microscope field; too much illumination will cause glare and obscure the cells.

Have the class study the diagrams and photomicrographs on text page 57. Develop the idea that a cell activity such as

protection is related to the shape or structure of the pavementlike cheek cell. Stimulate further discussion: "How does the shape of a nerve cell appear to be suited to conducting messages?"

Develop the idea that like cells are grouped into tissues. You may ask students to name the different tissues of a part of the body such as the leg: bone, muscle, nerve, blood, and skin. A film slide projector can be used to great advantage, especially with 2" × 2" color slides of tissues. These may be purchased from a scientific supply company. Microprojection of such slides is also a useful technique. The film *Cell, the Structural Unit of Life* is useful for further stimulation of discussion.

The cell as the building block of the body can be illustrated by making a chalkboard diagram from the outline on text page 56. Students can add side arrows to names of products produced by cells of the tissues and organs.

HELPING THE SLOW LEARNER

The slow learner may be interested in constructing cell models. A Plasticine model of a cheek cell can be constructed easily in various colors (to point out nucleus, cytoplasm, and other details).

2. *Our cells oxidize (burn) foods within them.*

To demonstrate oxidation of food outside the body, try burning a marshmallow. Burn it in an empty one-gallon jar with a lid. Ask the class to observe results (production of heat and moisture in the form of water droplets; and carbon dioxide, indicated by limewater turning milky). Ask pupils to explain why the flame was extinguished.

Some pupil may be familiar with procedures of a basal metabolism test. Or the school nurse (if one is available) can be interviewed by a committee of pupils and asked questions about metabolism tests. "Does the rate of oxidation in our cells vary from interval to interval? Explain." This type of question can lead to class research. Questions about the effect of cold weather on body cells, of disease-causing organisms on body temperatures, etc., will lead pupils to see that heat energy production in our bodies varies from time to time.

The activity on text page 59 can be used to show that our body temperature remains fairly constant when we are well, although we may be engaged in different types of activities.

HELPING THE SLOW LEARNER

The slow learner will be able to take a series of thermometer readings before and after exercise. From this data, the class may be able to understand that although our cells produce more heat at certain times, our body can also lose heat rapidly, thus maintaining a constant temperature range.

3. *Foods supply us with materials needed for growth, for repair of tissues, and as energy sources.*

After having elicited that there are several reasons for eating foods (to satisfy hunger, for health, etc.), suggest a research activity on food intake by each pupil. Have pupils list all the foods they ate the previous day—or keep a record of the type and amount of food they ate for three days. Charts may be constructed and, if you wish, supplemented by illustrated tabulation sheets obtained from cereal manufacturers such as General Mills. These charts can be used for discussion, introduced by the hamburger chart (for example, text page 62). Develop the idea that the important nutrients contain basic chemical elements. The first letter of each of the elements—carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur—can be used to introduce the idea that chemists use *symbols* in their equations of reactions and in calculations. It may interest the class to see the chemical formulas illustrated on the board with different color chalks; for example, show water as two hydrogen atoms and one oxygen atom (H_2O) in two colors.

Why do we need nitrogen for tissue repair? Ask the class to suggest a source of nitrogen. (Nitrogen in the air is not available to the body. We give off the same amount of nitrogen that we breathe in.)

Pupils will appreciate the opportunity to make various tests for nutrients, as described on text page 73. A heat source for the test for simple sugars such as dextrose may be either a gas flame, an alcohol lamp, or a small Sterno stove. It is important to warn children of overheating Benedict's solution—for the contents of the test tube may shoot out suddenly. Use no more than one inch of the reagent in the Pyrex test tube; heat gently.

Films like *Foods and Nutrition* (see listing of films and filmstrips on Manual page 61) and *What Makes Us Grow* are helpful in stimulating interest. The latter film may help pupils understand the usefulness of such animals as laboratory rats in diet experiments.

A free 305-page book, *Food for Life*, edited by Ralph W. Gerard, is available from the Continental Baking Company. The teacher who is planning a more thorough approach to the concept, as well

as the bright child who is interested in further fascinating details, will find the book helpful. Some of the excellent diagrams may be the basis for class charts.

HELPING THE SLOW LEARNER

The slow learner may be assigned to care for animals used in any nutrition experiments undertaken. Suggest specific tasks; a posted chart of these duties should be checked off daily. The diagrams on text pages 63-64 should be explained carefully.

HELPING THE RAPID LEARNER

The rapid learner appreciates opportunities for independent investigation. Have him analyze the vitamin C content of two different canned grapefruit juices, following directions on text page 74. He can report on his observations; then encourage the class to state conclusions as to the vitamin C potency of the two brands. What effect has bicarbonate of soda on vitamin C strength? Ask the class how they would check on this question. Obtain ascorbic acid pills from a druggist, dilute with water, and have the pupil make a comparative analysis for vitamin C in solutions of varying dilution. Perhaps the bright pupil can study the nutrients and calories the school lunch program provides.

CHAPTER 4: YOUR BLOOD WILL TELL
(text pages 79-99)

• CONCEPTS AND KEY ACTIVITIES

1. *Blood consists of cells floating in a watery plasma.*

Ask the class why blood transfusions are sometimes needed. Perhaps someone in a pupil's family has been a blood donor. Obtain an empty plasma or whole blood bottle from the local hospital. Read to the class the specifications on the label. Then go to the importance of blood, including its functions.

Visual Analogies. An idea of the amount of blood in the body can be illustrated by showing five quart bottles of water colored with red ink. Use a model of a red blood cell made of modeling clay (Plasticine). Shape it in the form of a biconcave disk.

Reading Lesson. The American National Red Cross, Washington, D.C., will send a free class set of *The Story of Blood*. After fifteen minutes of reading, begin discussion of the importance of blood. List the materials found in the plasma. A reading lesson of this type is valuable at intervals throughout the term.

Film. A free film such as *Hemo the Magnificent* is a good general approach to the concept. Color slides of red and white blood cells may be projected on a screen. Pupils should notice the differences in shape.

2. *Food must be in digested form before it can get into the plasma*.

Lead pupils to suggest possible functions of such organs as the stomach and small intestine. Copy on the board the diagram on text page 84. Utilizing information from the previous chapter, develop the idea that cells line the cavity of the small intestine. The cell membrane allows only simple nutrients to pass through it; complex nutrients must be broken down to a simple—digested—form.

Filmstrip. Frames 3 to 14 of the Harbrace filmstrip *Your Life Stream* are excellent to bring out additional ideas centering around the concept of digestion.

Demonstrating Selective Diffusion of Materials. After the class has had an opportunity to see that glucose is a simple carbohydrate as compared with starch, prepare a demonstration: Fill one test tube halfway with glucose dissolved in water and a second tube with some starch in water. Cover each tube with a piece of wet goldbeater's membrane, held in place with a rubber band (special dialyzing cellophane tubing from a scientific supply house is a good substitute). Invert both tubes and place each into a separate tumbler or beaker one quarter filled with water. Test samples of water from the beaker the next day for presence of starch and glucose. Ask the class to account for the passage of glucose into the water. Ask the pupils how they might devise a procedure to show that a digested starch can pass through the membrane. Use boiled starch water which has cooled; add a small amount of saliva. Emphasize the need for adequate controls, such as running a test for glucose in saliva and in a starch mixture in advance of the demonstration.

Film. *Digestion of Foods* shows a number of good demonstrations, including the effect of saliva on starch, gastric juice on protein, and pancreatic juice on fats.

HELPING THE SLOW LEARNER

To help the slow learner understand the diagram on text page 84, use colored arrows to represent the action of the three main

enzymes (amylase, or starch-digesting; protease, or protein-digesting; lipase, or fat-digesting). Let him draw a larger chart in color for the class bulletin board. Such contributions go a long way toward helping the slower child realize that he is usefully participating in the class work.

3. *In the lungs air moves in and out of the blood stream.*

Important components of the air, such as oxygen, carbon dioxide, and water vapor, are exchanged with our surroundings. Review the source of the body's carbon dioxide, oxygen, and water vapor. See that students understand that body cells give up carbon dioxide to the blood, which carries it to the lungs; oxygen is taken from the blood stream by the body cells. Make it clear, through discussion, that oxygen from the air is of no use to the body until it reaches the cells.

Filmstrip. The Harbrace filmstrip *Your Life Stream.* Frames 15 to 23 can be used for discussion.

Analogies. The suggested project on text page 88 may be modified by using a transparent pint plastic (ice cream or potato salad) container. With a heated nail (about ¼" in diameter) held in a pair of pliers, make a hole in the bottom; force a short length of rubber tubing into it to simulate a windpipe. A piece of rubber sheeting tied over the open end of the container can simulate the diaphragm. Although this type of model is often useful to illustrate how a part of the body works, some incorrect ideas may be picked up. For instance, point out that the walls of the container do not expand but that the chest cavity walls do.

If a round-bottomed glass flask is available, thin red and blue lines may be drawn to simulate capillary distribution around an air sac.

Using Specimens. Obtain fresh beef lungs with attached windpipe from a butcher. The class may be able to improvise a bell jar set-up, substituting the real lungs for the balloons. If a jar is not available, force some air down the windpipe and inflate the lungs; have the class observe the elasticity of the lungs as air enters and leaves them.

HELPING THE SLOW LEARNER

A simple activity such as counting the number of breathing movements before and after exercise can be performed by having students work in pairs. Also, the relative amount of carbon dioxide production before and after exercise can be studied by breathing through a straw into a measured amount of bromothymol blue. The indicator changes from blue to yellow in the

presence of carbon dioxide. Have the pupils record the number of seconds it took for the color change to take place before exercise and afterwards.

4. *The heart and blood vessels enable many materials to travel throughout the body.*

Start discussion by referring to the demonstration of blood flow in the tail of a fish or to newspaper stories of people revived after their heart has stopped beating. You may wish to have observations made on a fresh beef heart, one that has not been trimmed for sale. We have found the following procedure quite helpful: Place a piece of red rubber tubing through the right auricle, right ventricle, and into the pulmonary artery. Place a piece of black rubber tubing (or other material) through the left auricle and left ventricle, and into the systemic aorta or main artery to the body organs. The pupils will be able to trace blood flow with ease.

Studying Pulse Rate. Strong contractions of the ventricles result in blood being forced through the arteries in spurts. Most pupils are aware of this pulsation in an artery close to the skin surface. The neck, temple, and wrist are good places to note this pulse. Have pupils work in pairs (boys with boys, and girls with girls) and take each other's pulse. Make counts before and after exercise.

Field Trip. Arrange a field trip to a medical laboratory; preliminary discussion should result in formulation of specific questions based on reading of the text. The class, or a representative committee, can view some of the techniques in blood study.

Charts. Large charts of the general circulation, as well as that of the heart, can be constructed by some of the pupils. As a committee, they are to be responsible for explaining their work.

Films. *Circulation* (UWF) and *Heart—How it Works* (McGraw) can be used both to introduce and to review the concept.

HELPING THE SLOW LEARNER

Cutaway models of the heart, made of modeling clay of various colors, can be constructed easily, using the diagrams on text page 92 as guides. If a diagram of a frog's heart can be obtained (see a high school biology text), an additional model can be made for comparison. Pupils may listen to their own heartbeat by fashioning a stethoscope from a funnel and rubber tubing. If a Y-tube is available, rubber connections for both ears may be made.

5. *The blood moves cell wastes to body removal centers.*

Ask why a person whose kidney functions fail as a result of disease or accident cannot live. Cell wastes such as urea are removed chiefly by the kidneys. In above-normal concentrations urea is toxic.

Examining a Kidney. A fresh beef kidney, sectioned lengthwise, can lead to further discussion. Observe the large clusters of blood and blood vessels. Each kidney has about a million filters. Discuss the danger of a blow to the kidneys. Perhaps members of the class will want to construct models from soap or Plasticine.

Readings. Pages 193-202 of *Your Biology*, by Smith and Lisonbee, have excellent diagrams and information for the teacher, and for pupils interested in writing a report.

Charts. How the lung, skin, and liver act as waste-removal centers may be diagramed on large charts.

Analogy. Line a funnel with filter paper. Pour a mixture of liquid vegetable dye and sulfur particles into the funnel and notice that only the dye (representing water, urea, and some other plasma materials) goes through. The sulfur (representing complex blood proteins) does not. Bring out that the million kidney filters in each kidney work in the same manner. Water, other materials such as glucose and amino acids, and some urea are reabsorbed in the renal tubules, but the urea that remains leaves the kidney as urine.

HELPING THE SLOW LEARNER

The diagram on text page 96 should be discussed. Have the pupils make a similar diagram and add the name of the product to each of the heavy arrows shown. Point out that wastes in the large intestine are essentially undigested food wastes.

HELPING THE RAPID LEARNER

Refer to additional readings such as *Your Health and Safety*, which has an excellent presentation on the heart and circulation. "Wonders of the Heart," in the *World Book Encyclopedia*, also includes two pages of diagrams and statistics.

The rapid learner may wish to experiment further with the water flea described on text page 91. He may study what happens to the working of the organism's heart when a drop of 0.01 per cent Adrenalin is added to the slide. Additional heartbeat activities, with clams and embryo snails, are described on pages 70-73 of *A Sourcebook for the Biological Sciences*.

CHAPTER 5: YOUR BODY AGAINST UNSEEN KILLERS (text pages 100-17)

• CONCEPTS AND KEY ACTIVITIES

1. *Microbes, some being tiny animals and others minute plants, differ in appearance; most bacteria are harmless, but some cause disease; viruses are smaller particles that cause certain diseases.*

One way to introduce this unit is to use a chart for comparing the tremendous rise in life expectancy today with the expectancy of earlier years. Or you may wish to use another chart showing the sharp decrease in deaths from major diseases caused by bacteria. Ask for reasons for these changes.

Demonstration of Bacterial Colonies. The activity on text page 101 utilizes a nutrient agar, which may be purchased from a scientific supply company (see list of supply houses on Manual page 225). This demonstration will give pupils a chance to understand the need for careful technique and the importance of controls. If bacterial growths are found in the control dish, try to bring out how undetected errors may have crept into the experiment, leading to false conclusions.

Microscopic Examination of Common Bacteria. Obtain some sauerkraut juice or a bottle of yogurt. Prepare a thin suspension by diluting one drop of yogurt with one drop of water. Sauerkraut juice may be studied undiluted. A discerning pupil may insist that a plain drop of water be studied (as a control) in order to show that the bacteria obtained came from the yogurt or juice. Large bacilli will be plainly seen even under low power. From there, go on to discuss helpful and harmful bacteria.

Field Trip. If you can arrange for a trip to a local college bacteriological laboratory (or a hospital lab), the class can spend some time before the trip compiling a list of questions relating to their interests. Caution them that a good question results from thought and background information. Suggest that the text may furnish basic questions. It may be more feasible to arrange for a representative class committee to make the trip. A local physician may help you plan and arrange for the trip.

Suggested Research Report. Some pupils may wish to read about beneficial bacteria in a high school biology text or encyclopedia. Some of their discoveries, especially those relating to soil bacteria, can be discussed more fully when Unit 6, "Improving the World's Food Supply," is studied.

Suggested Films. *What Is Disease?* a Walt Disney film in sound and color, shows many microbes that cause disease. Free

filmstrips such as *Health Heroes* show the work of Pasteur, Koch, Reed, and other workers. Pamphlets on the same topics are available free in quantity. *The Winged Scourge,* another Walt Disney sound and color film, shows the animal microorganism that causes malaria, and pictures how the disease is spread. Another free filmstrip, *The Cancer Challenge to Youth* (American Cancer Society), presents facts about the nature, causes, and treatment of cancer, the areas of research, and what progress has been made in protecting individuals against it.

HELPING THE SLOW LEARNER

The photographs on text page 103 may be used to start simple Plasticine models of the three main types of bacteria. The pupil can place these three-dimensional models on plywood and print the name under each.

2. *Harmful microbes may enter through openings in the body.*

Start discussion with questions such as "Why are people told to boil their drinking water in regions which have been flooded?" "Why is it considered a poor practice to walk about without shoes, especially out-of-doors?"

Committee Work. Committees may help prepare large charts listing information about specific disease microbes under such headings as "Entry to the Body," "Examples of Disease Germs Entering This Way," "What Remedy or Precaution to Take." Perhaps pupils can cite personal experiences.

Films. *The Winged Scourge,* mentioned above, can be used to initiate further discussion about insect-borne diseases. If this film is shown, compare with diagrams on text page 108.

Committee Field Trip. A group of interested pupils might plan to interview the local public health officer and obtain data on the incidence of certain diseases. They should then present their information to the class.

Library Research. Reports on such topics as "DDT and Insect Control," "Malaria Control in the United States," and "The Housefly as a Carrier of Disease Germs" can bring additional enrichment.

HELPING THE SLOW LEARNER

The teacher may prepare a number of simple guide questions to direct the attention of the slow pupil to key ideas on text pages 105-08. For example, "How do typhoid germs enter the body?" is a key idea to explore further.

3. *Our body has several defenses against harmful microbes; man has made use of outside factors in the fight against disease.*

Start discussion by asking why antiseptics should be placed on cuts. Or why is it dangerous to squeeze a pimple? Or why is a white cell blood count taken when appendicitis is suspected?

Graph Analysis (text pages 110-11). Pupils will appreciate help in understanding the significance of the data presented by these graphs. "During what period was there a sharp drop in pneumonia deaths?" "What effect did pneumonia serum use have on the number of deaths?" Pupils who are given practice periodically in the reading of graphs (and active construction of graphs) will find other courses such as mathematics, science, history, and economics, which necessitate using graphs on occasion, easier to understand. With regard to the graph on page 111, point out that the increase in cancer deaths may be due to better diagnosis of the cause of death as compared to that of previous years.

Films and Filmstrips. Chemical defenses against disease are shown in the Harbrace filmstrip *Your Life Stream.* During the showing of this filmstrip, you may wish to have pupils tell what vaccines they have received which help form antibodies for prevention of specific diseases. *Man's Greatest Friend* tells about Pasteur's discoveries of a vaccine against rabies. A popular film, *Goodby, Mr. Germ,* is available free from your local tuberculosis organization. *Antibiotics,* an EBF film, shows the discovery, nature, and use of antibiotics. *From One Cell* shows in animation how cancer starts in normal cells and how it travels throughout the body; *The Traitor Within* portrays important facts about cancer. These two films are available on free loan from the American Cancer Society.

Additional Readings. *Your Health and Safety* (chapters 23 and 24) will be enjoyed by the pupils ready to read further. Send also for booklets and brochures from national health organizations such as the American Cancer Society, American Heart Association, National Tuberculosis Association, and health insurance companies.

Committee Research. A group of pupils can consult the school nurse (or school clerk) to determine the number of pupils ill during a given time. A chart may be prepared listing this data. Discussion can then follow for a review of good health practices.

Guest Speaker. A local physician (perhaps a relative of a pupil) may be invited to give a talk and answer questions on a suggested topic. Why not write up this visit for the school newspaper?

HELPING THE SLOW LEARNER

The slow learner may be able to arrange with the local pharmacist to collect empty antibiotic containers. These may be mounted

on heavy cardboard for display (see "Methods in Teaching About Antibiotics," *Science Teacher*, September, 1950).

HELPING THE RAPID LEARNER

The rapid learner may wish to ask his doctor to let him examine prepared slides of stained bacteria. If the school does not have a suitable microscope, try to arrange for the pupil to use a microscope at the high school (or a hospital or medical laboratory). Or he may wish to do "A Bit of Research" (see text page 117).

CHAPTER 6: YOUR COMMUNITY HELPS
(text pages 118-29)

• CONCEPTS AND KEY ACTIVITIES

1. *Our health is safeguarded by regular inspections of food and water. Proper sanitary methods and treatment of foods protect our health.*

Start with questions such as "How can you obtain safe drinking water on a hike or camping trip?" and "What is the advantage of pasteurized milk over raw milk?" The latter question may be preceded by having pupils observe the wording on milk bottle caps. Develop the idea that inspection of foods is a co-operative venture, with all citizens understanding the necessity for these measures.

Studying Labels on Food Products. The class can help assemble labels from cans and food packages which indicate compliance with provisions of the Federal Food, Drug, and Cosmetic Act. Bring out that government regulations and regular inspection are for our health protection.

Field Trips. Arrange a visit to a creamery, bottling plant, milking barn, or slaughterhouse. Lead pupils to an understanding of what controls the community has to prevent food contamination. A visit to a board of health office may give pupils a chance to question public health officials.

Films. *Community Health in Action* describes a community situation in which real efforts are made to improve the people's health. *Clean Waters*, a free General Electric film, presents a good story of water pollution and its results.

Committee Report. A group of pupils can prepare an exhibit of preserved foods (canned, dried, pickled, smoked) and pictures of frozen and refrigerated foods, and report to the class. They

should be asked to discuss the specific conditions which inhibit bacterial growth. Review health procedures in food preparation, especially cooking of meats; also, the process of milk pasteurization.

For the Bulletin Board. Pupils can contribute newspaper clippings and magazine articles on food poisoning, food preservation techniques (including radiation), and violations of the Pure Food and Drug laws. Pupils may be referred to issues of *Consumer Reports* and *Consumer Bulletin.*

Class Sanitary Survey. Divide the class into subgroups, each with a specific task, to survey the school building and grounds, including the school cafeteria, if there is one. Discuss the findings in class and have each committee draw up a list of practical steps pupils can take to keep their school clean, sanitary, and attractive. The lunchroom subcommittee may wish to invite the person in charge of the cafeteria to discuss problems of food and lunchroom sanitation.

HELPING THE SLOW LEARNER

Given a simple check list, the slow learners can share in the sanitary survey mentioned in the preceding paragraph. Data they gather can be utilized in preparing constructive suggestions for the class newsletter or school newspaper.

Some of these pupils can work out a simple skit in which they act out some of the duties of food inspectors (milk, meats, bakery products).

2. *Water is usually treated to make it safe for drinking.*

One way to start discussion is to show a tumbler of water into which a few spoonfuls of soil have been dumped. Stir this mixture and ask how it can be purified. Have students demonstrate filtration and then chlorination or boiling. (Some pupils will suggest using iodine or halazone; some will suggest distillation, etc.)

"How is our community protecting the water supply?" can lead to further discussion. "Explain why it is dangerous to drink untreated water from lakes and streams."

Class Models of Water Treatment Methods. Some of your students can construct a model of the filtering bed and settling basin described on text page 126. They may obtain alum and limewater from the high school or druggist. Models of water treatment apparatus are good projects for science fairs.

Field Trip. Outline the steps in water treatment before a field trip to a water treatment plant. Encourage the pupils to draw up specific questions in advance and ask additional ones at the plant.

Some pupils may be able to construct a model of the plant or draw an illustrated chart. Large city purification plants may have charts and other data on their activities. Why not write to them?

Films. *City Water Supply* (EBF) describes the sources of city water and the treatment it undergoes. The filmstrips *Making Water Safe to Drink* (Popular Science) and *Water Supply* (Academy) can be used to introduce or review the topic.

Readings. *Your Health and Safety*, 4th edition, Chapter 26, deals with guarding the community health. It gives information on public health agencies and their work.

HELPING THE SLOW LEARNER

A slow learner can easily demonstrate the activity on text page 122, showing why artesian well water comes to the surface. Or he may wish to enlarge, in color, the diagram on page 123.

3. *The health department safeguards the community against the spread of disease.*

Ask whether any of your pupils can recall having had a contagious disease. "What measures did your parents, your doctor, and the health authorities take to prevent others from catching it?" "How many have had a chest X ray?"

Field Trip. The duties of the health department can often best be understood by direct meeting with such public health officers as nurses, doctors, and technicians. Try to obtain a chart of the organization of the department and discuss the divisions and their duties after the class trip.

Readings. Send for the pamphlet *All Their Powers* from the Health Information Foundation. Try also to build a collection of pamphlets from your local health agencies for the school library.

Some students will be interested in making an intensive study of the World Health Organization and of the U.S. Public Health Service. A readable article on the duties of the Surgeon General, head of the latter organization, is found in the December 1958 issue of *Today's Health*.

HELPING THE SLOW LEARNER

This pupil can do an interesting project to illustrate the work of a health agency; it involves a controlled demonstration of mosquito destruction. Have him collect mosquito "wrigglers" and raise them in covered containers, adding oil to one of the containers of the developing insects. What is the effect of the oil film? Compare with the control (untreated) jar. He will

enjoy reporting his observations. "How else are mosquitoes destroyed?"

HELPING THE RAPID LEARNER

As an outcome of the survey of the sanitation of the school facilities more detailed investigations of the local health code may be made. We recall one study of the code by two rapid learners and a subsequent interview they had with the school dietitian. They asked many searching questions.

Refer bright pupils to *The History and Conquest of Communicable Diseases*, edited by W. Bett (University of Oklahoma Press, 1954). The control of contagious diseases such as typhoid fever, tuberculosis, and others is described.

Suggest to rapid learners that they study the records of the community health department and try to determine the chief health problems and procedures being undertaken. They may wish to arrange an interview with the head of the department and prepare a summary for the school newspaper or class newsletter.

Some rapid learners may be interested in organizing a school safety committee which can work with a similar committee of the Parent-Teacher Organization. They may co-operatively plan for an assembly meeting, posters, items in the school newspaper, etc., basing their approaches on ideas on text pages 129-31 which deal with accident prevention.

SUMMARY AND USE OF TESTS

The pupils should begin to understand, as a result of the study of this unit, that man's life span has been increased not only by discovery of new drugs but by many other factors. Pupils who understand the basic structure and functions of their body will be better able to comprehend good health practices. You can point out that basic instruction in the Air Force has the same concern. For example, pilots understood the reason for the many regulations about oxygen masks and their use when they saw the effects of oxygen-lack demonstrated by other pilots who had been placed in low-pressure training chambers. Stress that good citizens co-operate in maintaining good health standards. The fight against disease goes on constantly; newspapers, radio and television news reports, magazines and scientific periodicals bring us up to date, thus extending basic concepts in the text.

You may wish to use *Harbrace Teaching Tests* to accompany *You and Science*, Forms A and B. There are separate chapter and unit tests, as well as tests of interpretation, which may be ordered from Harcourt, Brace and Company. A key to these tests is at the end of this Manual.

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5. "Methods in Teaching About Antibiotics," *Science Teacher,* Natl. Science Teachers Assoc., September, 1950.

A LIFETIME HOBBY—SAVING YOUR OWN LIFE AND LIMB (text pages 129-31)

You may want to call to the attention of the class that this unit has included the idea of safety consciousness. One way to introduce the need for this section is to ask pupils to cite examples of corrective action in the community taken only *after* an accident. Discuss the importance of having thoughtful, creative citizens who can help others avoid accidents. Continue with pupil comments on the effectiveness of various safety campaigns.

Encourage pupils to maintain a bulletin board or notebook of news items and photographs of various types of accidents. Group together accidents in the home, at school, in the street, in the water, and in other places. For each accident, the pupil can write

a comment suggesting how the incident might have been avoided. A committee might interview a responsible official of the local police or fire department and ascertain the accident problems prevalent in the community.

To strengthen the hobby of safety awareness pupils can write to life insurance companies for safety pamphlets. Members of a committee can each write a different company requesting sufficient copies for the entire class to use. The National Safety Council maintains records of accidents, including automobile mishaps.

Some pupils may wish to prepare material for a discussion on "Should tackle football be played by ninth graders?" They may find it interesting to interview high school football coaches and physicians, including orthopedic specialists.

Another group might study the problem of hernia. How to pick up heavy objects by using back or leg muscles can be demonstrated. Consult industrial concerns, physicians, and physical education teachers for helpful hints.

UNIT 3 | *Exploring the Earth and Space*

GENERAL THEME: *Man is but one of millions of living things which have become adapted to conditions on earth. The earth is one of a family of planets that get energy from the sun.*

The study of heavenly bodies begun in earlier grades is now widened to give the child further understanding of the universe. We begin with an explanation of the solar system, including a description of the sun, the planets, and their orbits. The child then goes on to study the stars and the measurement of star distances, with particular attention to the position and size of the earth in relation to the size of the universe (text pages 135-46). A review of the conditions necessary for life on our planet is then compared with conditions believed to exist on the surface of other planets (pages 146-50).

The child comes to realize that the earth's position in space in relation to the sun affects the length of days and nights, and also the computation of time (pages 151-56).

He sees that besides being in a state of continual motion in space the earth is in a state of continual change from earthquakes, weathering, erosion, and tides. Because the moon is the earth's satellite, the student studies what causes the phases of the moon and eclipses of the moon and sun (pages 159-81). And because so much interest has been aroused in the possibilities of space travel to the moon and other planets, the child now looks at the total problem of space travel (pages 185-98).

The Unit Inventory. Before commencing study of this unit, you will find it helpful to have the pupils test themselves on what they know of the general theme of exploring the earth and space (text page 132). Their answers and subsequent discussion will enable you to determine the points that need greatest stress. And you will also be better able to adjust your allotment of time to specific topics and supporting activities.

PLANNING AHEAD

So that you may plan in advance for a particular film or filmstrip, assemble needed equipment, or arrange for a field trip or other special program, the following items are listed for your convenience in the order in which mention is made of them in this unit. A more complete list of films, arranged by topics, appears on Manual page 202. Additional reading references will be found both in the following chapters and on Manual pages 210-221.

FILMS AND FILMSTRIPS

f = film   fs = filmstrip   c = color

Chapter 7

1. *Earth in Motion* (f), EBF, 1936.
2. *Exploring Space* (f), TFC, 1941.
3. *Exploring the Universe* (f), EBF, 1937.
4. *Infinite Universe* (f), Almanac, 1951.
5. *Neighbors in Space* (fs,c), Harbrace.
6. *Our Mr. Sun* (f,c), Bell Telephone, free loan.

Chapter 8

1. *Earth and Its Wonders* Series (4 fs,c), EBF, 1953: *Story of Volcanoes; Story of Ice and Glaciers; Story of Mountains;* and *Story of Rivers.*
2. *The Moon* (f), Int. Screen Org., 1953.
3. *Sun, Earth, and Moon* (f), Almanac, 1950.
4. *Tides* (f), Almanac, rev. 1957.

Chapter 9

1. *Earth Satellites: Explorers of Outer Space* (f,c), EBF, 1958.
2. *New Frontiers in Space* (f), McGraw, 1953.
3. *Rockets: How They Work* (f,c), EBF, 1958-59.

LABORATORY EQUIPMENT TO BE ASSEMBLED

Chapter 7

flour or chalk powder, modeling clay (various colors), marbles, basketball, balloons, aluminum foil, pictures of space suits, deep-sea diving gear, earth globe on axis, electric lamp, slate or dark-surfaced globe, colored chalk, graph paper—$\frac{1}{4}$" squares (40 sheets)

Chapter 8

plastic ball or (enamel or wooden) globe, metal ball on pendulum string, hammer, tray (enamel or wooden), filled with earth, tray (enamel or wooden) filled with grass sod, paper sheets ($8\frac{1}{2}$" × 11" or smaller), large plastic hoop, rubber ball (such as tennis ball)

Chapter 9

cardboard cylinder (1"-2" diameter), bare wire (for track), balloon, tin cans (one with shiny surface, one with black surface), aluminum foil-covered paper bags, dark paper bags

FIELD TRIPS TO BE ARRANGED

Visit to planetarium; trip around school grounds.

CHAPTER 7: OUR SUN AND ITS PLANETS
(text pages 134-58)

• CONCEPTS AND KEY ACTIVITIES

1. *The solar system includes the sun, its planets and their satellites, tiny planets or asteroids, and comets and meteors; the planets follow orbital paths around the sun; bodies in the solar system have definite characteristics.*

One way to introduce the concept is by capitalizing on events of great current interest. For instance, the teacher can refer to the artificial satellites and their paths in space. Elicit from your pupils some of the important points which they might consider. Place these ideas in the order the pupils propose them (one of your brighter pupils, acting as secretary, can jot them down on the board). Then go to the make-up of the sun and its family; the place the earth occupies in this scheme of things will then become clearer. After this the class may be ready to organize the items suggested into a logical continuity. Some students may express interest in looking up additional details about one of the items on the board. You may wish to suggest specific committees (research about planets, etc.), or pupils and teacher can utilize the data in the diagrams on text pages 136-37 and develop activities.

"Walking" Models of the Solar System. After developing preliminary charts and "solar system blueprints" (relative sizes of planets and their distances from the sun), the school playground can be marked off with chalk or flour to indicate relative scaled positions of the bodies in the solar system. Each pupil can construct a sign which indicates the name and important facts about the planet. The paths of each planet can be indicated and each child can participate, walking along the respective orbit at a definite rate. This demonstration should produce interesting discussion.

Scale Models of the Solar System. Scale models to stimulate further inquiry may be constructed with modeling clay, marbles, basketballs, or balloons. Suggest each sphere be enclosed in aluminum foil and suspended from one end of the room (suggested dimensions: Mercury 3/8" diameter; Venus, 15/16"; Earth 1"; Mars, ½"; Jupiter, 11"; Saturn, 9½"; Uranus, 3 ¾"; Neptune, 4¼"; Pluto, approximately 7/16").

Field Trip. If your school is near one of the planetariums listed on text pages 139-40, write to the director for descriptive publications and ask for convenient dates for a class visit.

Films. *Our Mr. Sun* is a 60-minute discussion of the sun's composition, its energy, radiation, and solar storms. *Exploring*

Space portrays an imaginary rocket flight with close-ups of planets and stars. *Exploring the Universe* demonstrates constellations, while *Infinite Universe* dwells on galaxies and distant stars. *Neighbors in Space* (filmstrip) is excellent for both introduction and review. It is based on the textbook.

Readings. *Stars*, one of the Golden Nature Guides, is helpful for both teacher and pupil. It is profusely illustrated, and the tabular data on pages 104-05 can be used in student projects.

HELPING THE SLOW LEARNER

Suggestions for homemade planetariums are given in *A Sourcebook for the Physical Sciences* (see bibliography). One of them involves a paper-roll type which makes use of a lantern-slide projector. Use black paper made into a roll about 3½" wide. First copy the constellations from star charts onto the paper with white crayon; then punch holes according to the brightness of the stars. A standard size (3½" by 4") projector with the slide carrier removed will carry the paper roll. Put one end of the strip into the slide compartment, use a mirror to throw the beam from the projector onto the ceiling. Slowly pull the black strip through the projector.

Your slow readers may get help from such books as the *Golden Book of Astronomy*, with its simple wording and many colorful illustrations. *Fun with Astronomy* has many activities suitable for the slow reader.

2. *The conditions for life as it exists on earth vary considerably on the other planets.*

You may wish to lead into the concept by referring to the photograph of the helicopter over the Antarctic on text page 133. "What unfavorable living conditions exist in Antarctica?" Continue with discussion (led by a student chairman, if feasible) on desert conditions which produce unfavorable reactions on man. "How have fliers managed to survive unfavorable conditions at high altitude?"

You can develop discussion of the section dealing with conditions on other planets (text pages 149-50). Refer to the five conditions of life you have listed on the board and ask pupils to compare them with the data described in the text. As a result of pupil questions, suggest forming a committee on planetary conditions to do library research. Information about a possible expedition to Mars can be obtained.

For the Bulletin Board. Have your pupils assemble pictures of equipment worn by man in his attempt to adapt temporarily to abnormal surroundings (space suits, skin-diving apparatus, deep-

sea diving suits, oxygen masks, electrically-heated clothing, etc.). For each photograph have a caption provided to indicate the condition for life which the equipment satisfies.

Readings. *Satellites, Rockets and Outer Space* by Willy Ley (New American Library, Signet Key Book, 35¢) has a chapter about conditions on Mars. The book is easy to read and may prove helpful when Chapter 9 is studied. Why not suggest your pupils start building up a personal library of soft-covered (paperback) books which sell for 35¢ or 50¢?

3. *The rotation of the earth on its axis results in night and day; the tilt of the earth's axis as the earth revolves around the sun results in the changing length of nights and days; time differences are related to the earth's rotation.*

Your pupils' earlier work in science will no doubt influence your approach to these concepts. Ask pupils to give their ideas on causes of day and night. "How can we show that the spinning earth in relation to the sun will result in light and dark?"

Demonstrating Rotation and Revolution. Assume the sun to be in the center of a circle of pupils. Have them pass a basketball around the circle from left to right (west to east), then right to left. Which way does the earth move around the sun? Have them distinguish between this movement (revolution) and rotation. Twirl the ball into the air to show rotation.

Refer to Fig. 65 on page 152. Have a pupil walk in a circle around the bright lamp (the sun), slowly spinning the globe on its axis as he carries the "earth" around in its orbit. If possible, have him give the globe one spin for every degree of movement around the circle. (The wider the circle, the more accurate the results.) As he moves around the darkened room, the other pupils will see the lighted portions (daylight) and the darkened areas. In this and the next demonstration point out that the earth's axis maintains a fixed angle as it revolves about the sun (electric bulb).

Demonstrating the Differing Lengths of Days and Nights. Use a slate globe or an old, worn globe painted black. In colored chalk mark the equator and the Tropics of Cancer and Capricorn. Mark with an "X" the spot where you live; a different mark can represent a locality in the Southern Hemisphere, or a point 5,000 miles away at the same longitude.

Identify the position of the earth in your locality at the summer solstice (June 21); winter solstice (December 21). Which one represents the longest day in the year (for the Northern Hemisphere)? Allow as many pupils as possible to go through the physical motions of the analogy.

Films. *Earth in Motion* (EBF), describing the relation of the earth to the sun, can be used for review.

Constructing a Graph. To show the changing hours of light and dark throughout the year, students may consult an almanac for the time of sunrise and sunset for each day. (Some calendars include similar information.) To simplify the procedure, record in tabular form the time of sunrise and sunset for the first day of each month. On paper have pupils indicate on the abscissa the first day of each of the twelve months and on the ordinate the even hours of the day from midnight to midnight. Next, have them mark the tabulated data on the graph, shade the portion representing night, and generalize observations from their graphs. Some pupils may be interested in preparing similar graphs for Fairbanks, Alaska.

HELPING THE SLOW LEARNER

Encourage them to try the third activity on text page 151 (use a table lamp, with shade removed). They will enjoy searching for news clippings and bringing them in for the bulletin board, but they should understand that the teacher and their classmates will have the responsibility for extending the information. Of course, let him provide as much as he is able to.

HELPING THE RAPID LEARNER

A committee of your brighter pupils may preview the Harbrace filmstrip *Neighbors in Space*, mentioned on Manual page 80. One of them may act as chairman in presenting the filmstrip for discussion. What frames to show, what supplementary equipment to assemble, what reading research to present to illustrate further the ideas in the filmstrip—these may be worked out in committee meeting. The Harbrace filmstrips are accompanied by a booklet, *Teacher's Lesson Plans for Harbrace Filmstrips*, which reproduces the frames in sequence followed by questions at the end of each filmstrip unit.

The rapid learner may build up a library of inexpensive science books. Marshack's *The World in Space* (Dell, 35¢) has a very readable chapter on the sun. *Frontiers of Astronomy* by Fred Hoyle (Mentor, 50¢) is more detailed; however, Chapter 5 discusses the moon and the planets.

The International Geophysical Year of 1957-58 has uncovered many new ideas still being analyzed. The January, 1959, issue of *Natural History* presents a simplified outline of some of the main fields studied (most of your class of average and bright children will be able to follow it).

Your interested student should become acquainted with *Sky and Telescope*, a monthly publication of the Sky Publishing Company, Harvard Observatory, Cambridge, Massachusetts. The articles

on astronomy and advertisements by war surplus and optical firms may give leads toward the purchase of equipment for constructing telescopes.

CHAPTER 8: OUR PLANET HOME—AND ITS MOON (text pages 159-84)

• CONCEPTS AND KEY ACTIVITIES

1. *Various forces on earth cause it to change constantly; the sun and the moon exert a pull on the earth.*

You may wish to start with the idea that although our earth, a moving platform in space, makes periodic orbits around the sun, it is also subject to both internal and external forces.

An Account of an Earthquake. One way to introduce the concept is to read an eye-witness account of an earthquake. A handy source is chapter 7, "The Solid Earth," of *The World in Space* (see bibliography on page 92). Or you may have pupils assemble accounts of famous earthquakes. Where are quakes most frequent? What causes them? How are earthquakes measured? These questions may be anticipated; you may wish to use the next activity to help pupils understand and answer some of their own questions.

Demonstrating a Seismic Wave. Fill a hollow metal or plastic globe with water. From a ringstand hang a small metal ball so that it is in contact with one side of the water-filled globe. The outer skin of the large globe represents the earth's crust; the water is the plastic core.

Now with a hammer hit the side of the sphere opposite the hanging ball. The wave will travel through the water and push against the ball. If a thin, stiff wire and crayon are attached to the hanging ball, the outward kick can be recorded on a sheet of paper set up next to it and supported behind it.

Demonstrating Soil Erosion. After a rain, collect some muddy water, allow it to settle, and observe the sediment. Or simulate rain water runoff by filling a rectangular container with soil; tilt it at an angle, and saturate it with water from a watering can. How can we cut down the soil runoff? Use a second container covered with grass sod. Extend the concept by asking how runoff can be reduced on barren sloping land (terracing, contour plowing). Various illustrations to bring out the idea of "erosion" can include descriptions of familiar events or analogies. (Unwise methods of

toothbrushing may result in gum irritation or wearing away of gum-line tissue.) For additional activities, see *A Sourcebook for The Biological Sciences*, pages 236-40.

Field Trip. Have the class look around the school grounds to discover evidences of weathering such as cracks in concrete walks (how prevented?), effects of tree roots on walks, possible peeling away of layers of exfoliated rocks as a result of cracking resulting from alternation of hot and freezing temperatures.

Demonstrating the Pull of Gravity. After discussing Newton's findings on gravitational effects (text pages 166-67), have pupils calculate the gravitational force they would experience if they were on the moon (1/6 of their body weight); on Jupiter (see problem on text page 167; a person on Jupiter would weigh 2.64 times his "earth" weight). This discussion may result in questions as to whether some objects fall "faster" or "slower" than others. Try these:

a. Release at the same time a pencil and a flat sheet of paper whose width is equal to the length of the pencil. Which hits the floor first? (The shape of the object and the air resistance acting on it cause different objects to accelerate at different rates.)

b. Now roll the sheet of paper tightly into the shape of the pencil (bind with Scotch tape). Again drop paper and pencil together. How do their rates of fall compare now? Ask pupils to explain.

Studying Tidal Diagrams. You may want to have pupils reproduce on the chalkboard, in colored chalk, the diagrams on text page 168. A discerning pupil may ask why a bulge of water (high tide) is shown on the side of the earth opposite the moon, in the diagram at the foot of the page. The solid earth toward the moon is attracted more than the ocean opposite the moon. Water for both of these bulges is drawn from the ocean areas between them. Have the class note the depressions, or low tide.

Films. *Tides* can be used for review; the film explains the changing tides. Why not use it with the diagrams on text page 168? The series *Earth and Its Wonders* (EBF) includes filmstrips on volcanoes, ice and glaciers, mountains, and rivers.

HELPING THE SLOW LEARNER

Assemble reprints of articles from *Life* Magazine (see Manual page 224 for address). You may obtain them at nominal charge from the publishers. A special edition of *The World We Live In* for young readers will be of benefit. Part II, "The Face of the Land," is abundantly illustrated and has a simplified text. Suggest bulletin board displays of diagrams from these reprints, with printed titles indicating earth changes.

2. *The earth's moon appears in phases; at times it may hide the entire sun or part of it; the earth's shadow may hide the moon or part of it.*

Ask the class why we see only one side of the moon. Develop discussion with the following demonstration.

Demonstrating Motion of the Moon. In a large circle arrange twelve pupils facing another pupil in the center who holds a basketball with a large "X" chalked on its surface. This pupil hands the "moon" to one of the twelve pupils; instruct him to hold the ball so that the "X" faces the observer in the center. Pass the ball around the circle keeping the "X" toward the center. Note that the ball rotated just once during one complete revolution about the "earth." Have the class compare the way the moon goes around the earth with the way the earth goes around the sun. The moon keeps one side toward the earth. Discuss the possibilities of observing the 41% of the moon hidden from view. Can a satellite armed with TV cameras be placed in orbit around the moon? Describe the 1959 efforts to place a satellite in the moon's vicinity and any other recent moon probes. (The Russian Mechta I and the American Pioneer IV missed the moon and were drawn into orbit around the sun, and in October 1959 the Russians succeeded in obtaining pictures of the far side of the moon.)

Demonstrating the Phases of the Moon. The activity on text pages 171-73 can be done with a lamp, an old rubber ball, and a hoop. Slit the ball and place it on the rim of the hoop. Have a pupil inside the hoop hold it with both hands so that the rim is at eye level. He can observe the completely illuminated face of the moon (rubber ball) as he stands with his back to the lamp (full moon) if he tilts the hoop (the moon's path) about five degrees. Otherwise, his head, which represents the earth, will cast a shadow on the moon, creating an "eclipse" of the moon.

Ask why there isn't a solar and a lunar eclipse each month. (The moon's orbit shifts upward or downward a little while the moon circles the earth; consequently, no lunar eclipse takes place because the moon usually passes slightly above or below the earth's shadow at most full moons. Use the hoop analogy so that pupils may answer their own questions about a solar eclipse at the time of the new moon. Place the moon directly between the earth and the sun to show a total solar eclipse. Inasmuch as the moon's orbit shifts upward or downward a little in relation to the earth, the new moon is usually higher or lower than the sun; hence no eclipse takes place.

A Class Play, "Expedition on the Moon." A committee of pupils can imagine they have visited the moon as part of a scientific team. (Encourage imaginative titles such as, "Astrophysical Research Expedition of 1985," etc.).

Pupils can represent an astronomer, geologist, meteorologist, physicist, and biologist. Library research about the moon will yield interesting data. Chapter 4 of a delightful booklet, *Operation Moon*, by R. Will Burnett, will be quite helpful for your youthful researchers. Also, "Exploring Our Neighbor World, The Moon" (*National Geographic*, February, 1958).

Films. *The Moon* presents data useful for class discussion. The film *Sun, Earth, and Moon* explains reasons for day and night and shows relationships between these bodies.

HELPING THE SLOW LEARNER

The exercise on gravity effects (text page 183) may be performed at home. Encourage the pupil to improvise with additional objects.

Simple reading material from the *Golden Book of Astronomy* (large, colorful illustrations) will give the slow reader background material. Another "easy" reference is *The True Book of Moon, Sun and Stars* by John Lewellen.

HELPING THE RAPID LEARNER

Further enrichment in the concept of earth changes can be based on investigations of the IGY (International Geophysical Year). Margaret Hyde's *Exploring Earth and Space*, Alexander Marshack's *The World In Space*, and the January 1959 issue of *Natural History*, are excellent jumping-off points. The *Readers' Guide to Periodical Literature* will list more recent articles.

The student's findings can be summarized in a report, in a science newsletter, or as a poster on the bulletin board.

CHAPTER 9: SPACE, OUR NEW FRONTIER
(text pages 185-202)

• CONCEPTS AND KEY ACTIVITIES

1. *Rockets and satellites are telling us more about the earth and outer space.*

2. *Problems dealing with thrust, gravity, fuel, and man himself must be solved before man can travel into outer space.*

3. *Man in space must be protected from the dangers of gravity, pressure, temperature, and radiation*.

Suggest that the pupils imagine they have had the honor of being selected as the first passengers in a space rocket. What questions would they want answered before they accepted the offer? Can they think of obstacles to a flight at the present time? From this point develop the concepts.

Or you might ask students to bring in clippings or magazine articles which describe the Sputnik satellites (in IGY language: 1957 Alpha and 1957 Beta), the Explorer and Vanguard satellites, the rockets Mechta I and Pioneer IV, which became the first artificial planets around the sun—as well as more recent ones. Develop your approach by such questions as: What data has been sent to earth by some of these space vehicles? (The Explorer satellite transmitted signals describing the temperature of its outer skin, cosmic ray count, and number of contacts with tiny meteorites or cosmic dust grains.) How did man manage to get the payload (the satellite) out of the earth's gravitational field?

Reading About Recent Satellites. You might wish to utilize class interest in current events by allowing a supervised reading lesson. Text pages 187-89 tell of the satellites launched before 1959. Call on students to summarize the main idea of each paragraph. Examine Fig. 88 and call for opinions as to what might have happened had the rocket come under the influence of the moon's gravity. Extend by reference to Russia's hitting of the moon and sending a rocket into orbit around the moon in 1959; also, any data of more recent attempts. Also refer to Figs. 350 and 351 on pages 646-47 in connection with the "On Your Own" section. Brighter students may wish to construct and demonstrate a working model.

Circulate around the room and aid pupils who appear to read with difficulty.

For the Bulletin Board. A display of clippings and illustrations on space explorations will supply ready reference materials. Allow a pupil committee to supervise the listing on the bulletin board of titles of books on space travel, giving a thumbnail sketch of the high lights of each book. (See pupil bibliography of science trade books, including inexpensive paperbacked titles.)

Constructing a Rocket Model. Some pupils may wish to construct models of three-stage rockets, following the diagram on text page 190. Some hobby stores sell inexpensive construction kits. (Teachers may obtain a rocket kit from General Mills, Minneapolis, Minnesota, for 50¢.) Ask pupils to tell the role played by each stage. Discussion may lead to investigation of "research" problems. Why do some rockets fail to function properly? (The fuel may be insufficient to furnish enough power or thrust; electronic failure, etc.)

Demonstrating Rocket Thrust. A balloon may be filled with air and released. Pupils may recall what happens when one is standing on skates and pushes against a wall or when one jumps out of a rowboat onto a dock. Develop Newton's principle of action and reaction, and apply to rocket engine thrust.

Demonstrating a Model of an Earth Satellite. Photographs and detailed drawings on pages 131-46 of *Discover The Stars* may be followed by interested or rapid learners, resulting in a demonstration model. Willy Ley's *Man-Made Satellites* (revised edition) describes navigational, robot, and weather-televising satellites.

An Assembly Program. Since artificial satellites and their significance are often discussed in social studies classes, why not have an inter-class pupil-teacher committee plan an assembly program? Stress such information-gathering uses of satellites as: data for long-term weather predictions, the top of the atmosphere, the earth's magnetic field, data about the sun, and cosmic rays.

You might include a film, *New Frontiers in Space* (25 minutes), which has spectacular shots filmed from a rocket sent seventy-five miles into the atmosphere. The film shows the behavior of mice enclosed in the rocket.

How Man-Made Satellites Can Affect Our Lives, a well-illustrated article by Dr. Joseph Kaplan, in the December, 1957, *National Geographic*, discusses space problems. This article is useful for assembly programs and class discussion. (See additional references on Manual page 92.)

Filmstrip. One way of introducing the filmstrip *Neighbors in Space* (frames 25-36) is first to examine text Figure 94. Elicit, by questions, what is meant by a "g" (a force equal to the pull of gravity). The filmstrip shows a flying platform which produces lowered gravity conditions, a centrifuge, satellites, etc. If you wish, have a committee preview the filmstrip so that they may augment it by a report on space medicine. Extend the concepts with the suggestions given in item 1 of "Going Further."

HELPING THE SLOW LEARNER

Why not assemble a classroom library of easy-to-read books about space travel? (Moderate and rapid learners will enjoy them also.) *The First Book of Space Travel* is simply written. Include Willy Ley's four 48-page books: *Man-Made Satellites*, which describes construction of satellites and their value in research; *Space Pilots*, which describes the feeling of flying at zero gravity, the effects of acceleration, altitude and cosmic rays, and ways of protecting human beings against hazards of space travel; *Space Stations*, which describes how and why space stations will be built, launched, and maintained in orbit; and *Space Travel*, which is an imaginative tour in 1976.

Demonstrating Absorption of Heat. The slow learner may be able to contribute to discussion of rocket ships and exposure to heat rays. Obtain two shiny cans with narrow openings; paint one black. Insert a thermometer into 2 one-hole stoppers and fit each into the opening of a can. Allow sunlight to hit each can. Note the temperature difference.

HELPING THE RAPID LEARNER

Opportunities for leadership can be afforded in several ways: The rapid learner may organize a skit-writing group on such topics as "Living on a Space Station" or "Briefing a Space Pilot." Suggest he consult, in addition to references cited in this unit, current articles listed in the *Readers' Guide to Periodical Literature*.

Another skit can present the part played by the physicist, chemist, biologist, and engineer in the study of problems of space. Each actor can first cite some problems to be overcome and illustrate his presentation with a chart. *The Space Encyclopedia* is a handy reference. "Man in a Space Ship" is an excellent review article (*Science News Letter*, January 10, 1959).

Have the rapid learner investigate activities of the U.S. Aeronautics and Space Administration. A class newsletter can summarize news items of space launchings. A science-prone child can act as editor.

The rapid learner may like to prepare a graph relating the average height of a satellite to its period around the earth (see text page 201 for tabular data).

Some of the brighter pupils might build a model of satellite equipment inside a large, transparent, plastic beach ball, equipping it with a model airplane radio control transmitter and receiver. This model will show how man-made satellites can send messages back to earth.

For interesting reading, try *The Rocket Pioneers*, which presents a historical perspective from Jules Verne to the work of the American Rocket Society.

SUMMARY AND USE OF TESTS

The teacher can point out during class discussions that a proper understanding of current events depends on basic knowledge of ideas about our solar system, man's requirements for living, and physical principles such as thrust and gravity.

Stress that the study of later units may always be interrupted for consideration of important current events with regard to space explorations. This is a good time to point out that interested students desiring to learn more about space can continue long-term

projects on their own by starting the activities in skywatching developed on text pages 625-48. You can also ask how earth satellites can help in weather forecasting—and thus lead into the next unit.

Of course, the suggested order of units in the text may be varied; the teacher will recognize the desirability of study of a different topic, depending on his approaches and upon the needs and developing interests of his classes.

You may wish to use the *Harbrace Teaching Tests* to accompany *You and Science*, Forms A and B. These include several types of objective tests based on specific chapters. A test on the entire unit is also provided. You may obtain these test booklets from Harcourt, Brace and Company.

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14. Ley, W., *Space Pilots* (1957); *Space Stations* (1958); *Space Travel* (1958), Simon and Schuster.
15. "Man in a Space Ship," *Science News Letter*, January 10, 1959. Problems of creating an environment similar to that of earth within a space ship.
16. Marshack, A., *The World in Space*, Dell, 1958. Summarizes the IGY; holds pupils' attention.
17. Menzel, D., "Exploring Our Neighbor World, the Moon," *National Geographic*, February, 1958. Many full-page photographs; ideal for bulletin board displays.

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19. Wyler, R., and G. Ames, *Golden Book of Astronomy*, Simon and Schuster, 1955. Simple vocabulary and colorful illustrations, will appeal to the slower pupils.

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3. Jones, H. S., and others, *Space Encyclopedia*, Dutton, 1957. A guide to astronomy and space research.
4. Joseph, A., P. F. Brandwein, and E. Morholt, *A Sourcebook for the Physical Sciences*, Harcourt, Brace, 1960. Contains many practical activities.
5. Morholt, E., P. F. Brandwein, and A. Joseph, *A Sourcebook for the Biological Sciences*, Harcourt, Brace, 1958.
6. Watson, F. G., *Between the Planets*, Harvard University Press, 1956.
7. Williams, B., and S. Epstein, *The Rocket Pioneers: On the Road to Space*, Messner, 1955. Handy for historical background.
8. Zim, H. S., and R. H. Baker, *Stars*, Simon and Schuster, 1951. Handy classroom and out-of-doors reference for both teacher and pupil.

MODEL ROCKETS AS A HOBBY (text page 203)

A new hobby having a great appeal is the study and construction of rocket models. The general science teacher might sponsor a school Rocketry Club "sparked" by one or more interested students who can serve on a steering committee. One project can develop a history of rocketry illustrated by models and charts depicting early rockets. Have pupils attempt to visualize the appearance, based on their readings, of an early Chinese rocket and construct a small model. Do the same for the dry fuel rocket developed by Sir William Congreve which was used in the War of 1812. (This inspired Francis Scott Key to write of "the rockets' red glare" in our national anthem.) Other rockets by William Hale, Robert Goddard, and others may be depicted by models, accompanied by explanations of their construction and use. Add models of rockets used in World War II and in the postwar years, including the rockets mentioned almost daily in the newspapers.

Pupils interested in model rocket construction but not too skilled in handicraft may obtain plastic kits of rockets sold in hobby stores and assemble them.

It is very important to caution your pupils on the dangers of actual rocket firings. Cite newspaper descriptions of accidents experienced by youngsters (and adults!) who attempted to launch working rocket models with homemade rocket fuels. Except under unusual, controlled circumstances, ninth graders are not ready to attempt model rocket launchings—and then only under the guidance of competent authorities. The publications of the American Rocket Society will provide much information, especially for the bright youngster who wishes to read ahead.

Your rocketry club can discuss such topics as dry-fuel versus liquid-fuel rockets, rockets used in research, in war, for assists in take-offs of heavily loaded planes, in rescue operations at sea, and for carrying mail.

Various aircraft companies, such as Convair, Dept. 120, P.O. Box 1128, San Diego 12, California (write for their *Space Primer*), will be glad to send rocket literature. Students and teachers alike will appreciate a school exhibit by the rocketry group. Perhaps your club can help sponsor an assembly program of student-constructed rocket models, lantern slides showing outline drawings of these models, and a film such as *Rockets: How They Work* (see film listing on Manual page 80 for details). Models of rockets reported in the news always make an exciting presentation.

Your rocketry hobbyist will find *Rocket Power and Space Flight* by G. Harry Stine (Holt, 1957) quite readable. A list of suggested readings will be found on Manual page 92. Both *Jet Propulsion* and *Astronautics*, publications of the American Rocket Society, will attract the rapid learner who wishes to read ahead. Local rocket groups, educational centers, and major U.S. corporations engaged in rocket research and development are listed in the appendices of *Rocket Power and Space Flight*.

UNIT 4

Understanding the Earth's Weather

GENERAL THEME: *Understanding of the behavior of the earth's atmosphere has enabled man to predict weather changes and take measures to protect himself against them.*

To understand the earth's weather, the pupil needs to know the conditions that cause weather changes, such as the water cycle, variations in temperature, air pressure, amount of water vapor in the air, and the effect of heat from the sun. He will study what causes winds, the different kinds of clouds, dew, rain, snow, and hail (text pages 204-17). Next, he sees how weathermen predict weather changes, what instruments they use, and how to read a weather map (pages 219-39). Since weather changes are related closely to the seasons, the pupil studies the causes of seasons and seasonal weather changes (pages 243-53). Finally, he sees how man has learned to protect himself against weather; he studies clothing, housing, heating systems, air conditioning, and insulation (pages 256-68). As indoor heating requires the use of fire, simple rules of safety from fire hazards are discussed (pages 268-71).

The Unit Inventory. Before commencing study of this unit, you will find it helpful to have the pupils test themselves on what they know of the general theme of understanding the earth's weather (text page 204). Thus you will be able to discover background information and plan your time allotment to stress specific topics and supporting activities.

PLANNING AHEAD

So that you may plan ahead for a particular film, equipment mentioned in this unit, field trips, or special programs, the following items are listed in the order in which they are mentioned in this Manual. It is advisable to look through the activities given in this Manual for each chapter in this unit so that you may assemble in advance the materials you will need. A more complete list of films, arranged by topics, appears on Manual page 202.

FILMS AND FILMSTRIPS

f = film fs = filmstrip c = color

Chapter 10

1. *Nature's Plan* (f,c), EBF, 1953.
2. *Unchained Goddess* (f,c), Bell Telephone, 1958, free loan.

Chapter 11

1. *How Weather Is Forecast* (f,c), Coronet, 1953.
2. *Warning Tornado* (f), U.S. Dept. of the Air Force, 1955.
3. *Weather* (f), Almanac, 1956.
4. *Weather* (fs), Harbrace, 1957.

Chapter 12

1. *The Seasons* (fs,c), YAF, 1956.

Chapter 13

1. *Heat—Its Nature and Transfer* (f), EBF, 1958.
2. *How to Fight a Fire in the Kitchen* (f), Bureau of Communications Research, 1953, free loan through Natl. Board of Fire Underwriters.

LABORATORY EQUIPMENT TO BE ASSEMBLED

Chapter 10

tin can, can opener, tin snips, baling wire, lamp, hot plate, Bunsen burner, convection box (aquarium, heavy cardboard, 2 lamp chimneys, aluminum foil), candles, paper towels, slate globe, basketball, platform balance, one-gallon can (rectangular face), exhaust pump, dry ice, metal mirror, one-gallon glass jug, 4" glass tubing to fit 6" length of rubber tubing, milk bottle, thin rubber sheet

Chapter 11

mercury barometer, various weather instruments, centigrade and Fahrenheit thermometers, 250 ml. Pyrex beaker, ¼" square graph paper (40 sheets), milk bottle, rubber sheeting, glue, straw, cork, kettle with spout, glass plate, weather maps (series), large plastic sheets, wax glass-marking pencil

Chapter 12

lamp socket with metal-threaded extension bar, wooden strip (1" × 2" × 24"), globe, rubber ball, darning needle, 2 flashlights, modeling clay (1 lb.)

Chapter 13

hand magnifiers, compound microscope, 2 glass flasks (one blackened and one painted white), one-hole rubber stoppers to fit flasks, thermometers, 2 yardsticks, ball, 2 Pyrex beakers (500 ml., 50 ml.), sawdust, large nail, 2 Erlenmeyer flasks (250 ml.), asbestos sheets, paper cups

FIELD TRIPS TO BE ARRANGED

Visits to a weather station, a school heating plant, a building under construction, a fire station.

CHAPTER 10: OUR DAILY WEATHER
(text pages 206-18)

• CONCEPTS AND KEY ACTIVITIES

1. *We live at the bottom of a moving ocean of air; temperature and moisture are factors which affect air pressure.*

One way to start is to ask whether anyone has traveled in an airplane. Did he experience bumpy air? Cite the case of fliers who experience bumpy air when flying over hot desert areas. Have a pupil demonstrate the activity in Fig. 96 on text page 207, which shows that heated air rises. Discussion should bring out that wind is air in motion, and that differences in temperature are responsible for this motion. Ask pupils to devise their own demonstration to show that heated air rises.

Demonstrating the Rise of Heated Air. Attach thin streamers of lightweight material (paper, thread, cloth) to a glass rod (or pencil); they will rise in the warm air currents above a hot plate or Bunsen burner flame. Updrafts of warm air (often referred to as *thermals*) result in the bumpy air encountered by airplanes.

Demonstrating the Effect of Cooler Air. For this demonstration, you will need a rectangular aquarium tank (an oblong box will do) and a sheet of cardboard large enough to cover the top. In the cardboard, cut out a hole at either end over which glass chimneys may be placed. Line the undersurface with aluminum foil as a precaution against fire. Light a candle at one end of the container (convection box) and put the cardboard cover and the two chimneys in place. Ignite a slightly dampened paper towel and hold it over the chimney at the end opposite the candle. Smoke will be drawn in as the heavier, cooler air replaces the warm air rising above the candle. Now hold the smoking paper over the other chimney. Can the pupils account for the visualized air currents? Now refer to Fig. 97 on page 208 (or place the diagram on the board) and ask how the convection box demonstration helps explain sea breezes and land breezes.

Demonstrating the Effect of the Earth's Rotation on Wind Direction. After discussion of the effects of unequal heating of the earth's surface, have pupils use a slate globe that rotates on an axis to demonstrate the effect of rotation upon the wind direction. First, pour a small amount of water on the north pole of the stationary globe. Note how the water runs in the paths of the meridians toward the equator. (It is a good idea to mark the words "cold air" at the poles; "warm air" at the equator.) Now, dry the globe; spin it west and east, as the earth rotates, and pour a

little water on the top end of the rotating globe. When the globe comes to rest, trace the path the water took. Which way did the path of water curve in the Northern Hemisphere? The winds in the Southern Hemisphere are twisted to the left.

For the Bulletin Board. Have pupils prepare airline timetables showing comparison of flight times of east-west and west-east trips. Why does it take longer for planes to fly from New York to Los Angeles than in the opposite direction (headwinds due to prevailing westerlies). Of course, correction must be made for the crossing of time zones.

Demonstrating That Air Has Weight and Exerts Pressure. Weigh a basketball before and after inflating; an equal-arm balance is best. Or review the effects of air pressure on a one-gallon rectangular can as air is removed from it. Use an exhaust pump, or place a small amount of water in the can and set the unstoppered can over a hot plate or gas burner for 5 to 10 minutes. Remove the can and seal it with a cork or rubber stopper. Ask pupils to explain the distorted shape of the can. Can they calculate the total atmospheric pressure exerted on one face of the can? (14.7 pounds per square inch.) One teacher has one-inch squares ruled on the can before the demonstration.

Films. *The Unchained Goddess*, a free color film, may stimulate interest and serve as a general introduction to the concept. Various aspects of weather, including pressure areas, air masses, and storms are presented.

2. *The gas, water vapor, is an important constituent of air; this water vapor may condense to form small water droplets; the sun's heat energy causes our weather*.

Start the lesson by drawing a moistened paper towel across the chalkboard. As the streak evaporates, ask what is happening. Expand the idea of evaporation to relate it to the water cycle. Next, bring out the difference between invisible gas, water vapor, and the visible droplets of water by having a pupil breathe on the blackboard or a glass plate. Distinguish between condensation and evaporation, thus developing the water cycle concept.

Demonstrating the Principle of the Water Cycle. Hold a chilled mirror above an open pan of water on an electric hot plate. Have pupils point out evaporation, condensation, and precipitation (phases). If dry ice is placed against a chromium plate metal mirror, "snow" or frost will develop directly from the water vapor in much the same manner that snow forms from water vapor in the air.

Demonstrating Cloud Formation. Cover the bottom of a one-gallon glass jug with warm water; place a glass tube into a one-hole

rubber stopper and then insert it into the mouth of the jug. To the outer end of the glass tube attach a length of rubber tubing, the other end of which is fixed to a bicycle air pump (you may have to add to the pump an adapter needle valve similar to the one used to inflate a football). After several strokes of the pump handle, release the stopper and note a cloud forming immediately. The sudden expansion of the air in the jug (with resulting cooling) caused water vapor to condense in small cloud droplets. To improve visibility direct a beam of light on the jug.

Readings. Your pupils will enjoy chapter 9, "Increasing the Rain," in *Sun, Sea and Sky,* by Irving Krick and Roscoe Fleming. Cloud-seeding activities, using silver iodide, are described. This chemical can be very effective, as compared with dry ice.

Weather, a Golden Nature Guide, is a handy class reference. Pages 53-60 give a good description of the earth's general circulation.

Films. *Nature's Plan*, an EBF color film, portrays the water cycle. You may wish to introduce the concept with it, following up with some key extension activities in this chapter.

HELPING THE SLOW LEARNER

The activities on text page 218 can be set up by this pupil. Urge great caution in burning paper in the milk bottle. A modification in this activity consists in quickly placing a piece of rubber sheeting over the opening after the air has been heated. The rubber will be forced inward by the atmospheric pressure (and may rip apart with a loud noise).

HELPING THE RAPID LEARNER

Why not refer the rapid learner to *Weather Wise*, a publication of the American Meteorological Society, Boston, Massachusetts? He can demonstrate a number of simple experiments in this magazine.

Perhaps discussion on the earth's rotation and winds may encourage the bright pupil to seek more information. Then Harry Wexler's "The Circulation of the Atmosphere," in the Scientific American Book *The Planet Earth*, will help him build up more background. Or he may do some research and draw up a list of meteorological projects studied by the IGY program.

CHAPTER 11: PREDICTING WEATHER CHANGES
(text pages 219-42)

• CONCEPTS AND KEY ACTIVITIES

1. *We can measure weather factors such as air temperature and pressure, precipitation, relative humidity, and winds.*

One way to start is to have pupils recount unusual weather happenings and list them on the board, giving the date of occurrence. Then continue to keep a diary of unusual weather (suggest this be carried on throughout the term). If the daily newspaper includes a weather map, encourage your pupils to include maps with their report of unusual weather happenings.

Or you may prefer to reverse the above procedure and have pupils apply their knowledge of the concept, after they have read the text, in a discussion of the reasons for the different kinds of weather.

Another way to introduce the concept is to suggest plans for a class or school weather station. The pupils will have to find out what instruments will be needed. Form main committees, such as one on instrument-shelter construction, and subcommittees in charge of instruments such as maximum-minimum thermometers, psychrometer, weather vane, and anemometer. A homemade mercury barometer can be set up indoors (see directions on text pages 221-22). What factors will these instruments measure? Where can the subcommittees seek information about the activities of a weather station?

Field Trip. Contact the local weather station to arrange a visit. (It is advisable for the teacher to make a preliminary trip to the station and indicate to the person in charge what the level of the class is and the background of information they possess.) Ask the class to draw up in advance a list of questions which may serve as an outline.

Some classes have come back with discarded weather balloons, surplus sheets containing teletype data, and many photographs taken by members of the class. If you set up a school weather station, it may also become an amateur station contributing data regularly to the Weather Bureau. Apply to the U.S. Weather Bureau, Washington, D.C.

For the Bulletin Board and Newsletter. A committee can display photographs of weather instruments (including those taken on the field trip), drawings, and current weather maps.

Comparing Thermometer Scales. Insert a centigrade and Fahrenheit thermometer into a Pyrex beaker of water. Pupils can

help you take readings as the water is heated gradually and keep a tabular record of the temperature registered. Compare the readings of boiling water. Later, test a beaker containing ice and water. You may want to set this up as a laboratory activity, with groups of pupils working together. Suggest a chairman be appointed to coordinate the findings of the committees. An additional thermometer may be used which has *both* scales on it; this may be used for further comparisons.

Work out several temperature conversion problems (see text page 241), making use of the suggestions listed in the text. A convenient conversion scale can be prepared.

Preparing a Graph of Temperature Scales. To build up much-needed familiarity of graph construction and analysis, pupils can prepare a graph for converting from Fahrenheit to centigrade; represent Fahrenheit degrees on the ordinate from 0^{0} to 220^{0} F.; on the abscissa show centigrade degrees from -20^{0} C. to 120^{0} C. Mark the points where 212^{0} F. equals 100^{0} C., and 0^{0} C. equals 32^{0} F.; draw a straight line through these points. If drawn correctly, this line can be used for converting from one scale to the other. For example, change 20^{0} C. to Fahrenheit degrees. Read from the graph; also, solve as a problem and check with the problem discussed on text page 241. Then the pupils can graph the results recorded from the preceding demonstration. What may be the reasons for variable results?

Demonstrating Changes in Air Pressure. The Torricelli barometer described on text pages 221-22 may be used, but avoid shaking or moving it up or down abruptly (the mercury column may break the sealed end of the barometer tube).

Pupils may make a crude type of barometer from a milk bottle, thin rubber sheeting, and a paper straw. Stretch the sheeting across the mouth of the bottle and hold in place with a rubber band. Glue a straw on a very thin cork disk, and when this has dried, glue the cork to the center of the sheeting. Prepare a scale on cardboard and place this just behind the tip of the straw. Mark the current reading as given on a standard barometer, if possible.

Encourage pupil criticism of this project, in order to bring out reflective thinking. For instance, pupils may remark that heating of the air trapped inside the bottle may cause the rubber sheeting to bulge. How can we correct for this variable? (Keep the barometer in a part of the room where there is little fluctuation in temperature.) Bring out that temperature corrections must be made each time a standard barometer is read.

Summarize the barometer principle by explaining that moist air is lighter than dry air; therefore a falling barometer shows that the amount of moisture in the air is increasing.

Readings. *Weather*, a Golden Nature Guide (pages 6-13), has a simple, illustrated account of the sun as a weathermaker. Note

especially the chart on page 12 which effectively describes relative humidity. A pupil may wish to make an enlarged drawing of this chart, showing beakers filled in proportion to relative humidity. This chart will help the class relate temperature to relative humidity. See other references listed on Manual pages 112-13.

Films. *How Weather Is Forecast* shows the simple operation of a weather station and explains weather maps. You may prefer to substitute it for a trip to a weather station. The Harbrace filmstrip *Weather* helps develop the concept of the sun's role in the water cycle. See other references listed on Manual pages 95-96.

HELPING THE SLOW LEARNER

The slow learner can contribute to class activities in many ways: He can measure relative humidity of the classroom for three consecutive days, following the suggestions on text pages 226-28. He can construct a simple psychrometer from two similar thermometers, one of which has a small wad of cotton wrapped around the bulb. The results can be posted on the bulletin board. Additional suggestions may be obtained from *Everyday Weather and How It Works*, by Herman Schneider. The use of simple materials, especially milk cartons, for constructing weather instruments will appeal to the slow learner.

2. *Certain types of clouds mark the presence of weather fronts; fronts are formed by the meeting of different air masses; weather maps help us in making forecasts.*

Ask pupils to cite instances of dangerous weather conditions encountered by airplanes. The thunderhead or cumulo-nimbus is the most feared of our cloud formations; it can rip a plane apart.

Refer to the use of radar by air pilots to avoid bad flying weather. Radarscopes can pick out this cloud type as a distinctive "blip." Develop your discussion by further questions on cloud formation and cloud types.

Demonstrating Cloud Formation Around Dust Participles. See the activity on artificial clouds, explained on Manual page 99. A denser cloud can be formed by introducing additional "condensation nuclei" in the form of smoke particles (salt particles along our seacoasts serve the same function). Place a smoldering match inside the glass jug for a moment and repeat the procedure of forcing additional air into the jug. When the rubber stopper is removed, the rapidly expanding air is cooled with consequent condensation of water vapor around each of the tiny smoke particles. Visibility of the cloud may be improved by placing black paper behind the jug.

Demonstrating the Formation of a Weather Front. Boil water in a kettle with a spout. As the visible steam emerges, place a glass plate in it. Ask pupils to account for the formation of "rain." The warm, moisture-laden air (warm front) hits the cold glass plate (cold front) and "bad" weather results here.

Bring out that fronts form when air masses collide. One air mass pushes the other masses along; in a cold front, the colder air pushes under the warmer air and lifts it. A warm front is caused by warm air pushing over cooler air. Refer to the diagram on text page 235.

For the Bulletin Board (Weather Maps). Write to the U.S. Weather Bureau, requesting a five-day sequence of weather maps showing the advance of an intense storm across the country. If you use thin sheets of plastic or cellophane, you will be able to place colored arrows and other notations directly over the face of the map as discussion proceeds. (Use a ceramic or wax pencil.) Pupils can mark the highs and lows and indicate the former position of a front or origin of specific air masses.

Readings. Have pupils investigate how artificial satellites may soon be used to help man forecast weather more accurately. Refer them to the *Readers' Guide to Periodical Literature* (for example, Dr. Kaplan's article, "How Man-Made Satellites Can Affect Our Lives," *National Geographic*, December 1957, is helpful). Or the excellent paper-bound book by Alexander Marshack, *The World in Space*, presents concise, easy-to-read material (pages 181-82). Weather satellites carrying TV cameras could send back information showing where a storm was brewing; it could reveal cloud cover and the amount of radiation being lost from earth. The origin of hurricanes might be revealed in this manner.

Data on climate in your region (by states) can be obtained from *Climate and Man*, the 1941 Yearbook of the Department of Agriculture.

The influence of weather on war operations is told in chapter 8 of *Sun, Sea and Sky*. Pupils can make reports on how weather forecasts are used in agriculture, industry, etc.

Films. Call attention to telecasts shown daily on some networks. On rough outline maps students may sketch in quickly the position of a weather front as the announcer diagrams it in his broadcast.

Weather, an Almanac film, shows both a weather bureau station and a trip to the stratosphere. Contact the U.S. Air Force (public relations section) for free loan of *Warning Tornado*, which shows the difference between a hurricane and a tornado and pictures radar tracking.

HELPING THE SLOW LEARNER

Suggest that the slow learner use the Beaufort Wind Scale (text pages 228-29) to make a chart of wind direction and velocity of five cities indicated on the weather map on page 230.

Refer him to Part IV, "The Canopy of Air," in *The World We Live In* (a compilation of excellent colored drawings from *Life* Magazine). The text is written for young readers (special edition).

HELPING THE RAPID LEARNER

The rapid learner should have an opportunity to exert leadership and to make contributions based on research. For example, allow him to preview the Harbrace filmstrip *Weather* (based on the text), and select a section for class discussion. Then, with a committee of interested pupils, he can assemble additional materials (such as weather maps that show cold fronts or warm fronts) for display when cross sections of fronts (frames 27 and 28) are shown. Or the committee can lead a discussion, tracing back local water sources to their origins (and thus review the water cycle). Your bright youngsters will give ideas of their own when presenting some of these topics.

Have the rapid learner try to borrow an obsolete radiosonde from a weather station. A display of the contents will evoke much interest in these days of radio transmission from artificial satellites.

Suggest that the bright student interview the local forecaster or chief weather observer to discover the requirements for these jobs and the principal duties. With the right approach he might be invited to watch the ascent and tracking of a "pibal" or pilot balloon by means of a theodolite (text pages 230-31). He can investigate the use of radar in tracking balloons, closed circuit television for weather map transmission, and teletype transmittal of weather symbols.

He may like to read A. Spilhaus' *Weathercraft*, which tells how to assemble and operate a home weather station with materials obtained around the home or bought at a "five-and-ten" or hardware store. Or if he likes to dabble with electrical equipment, suggest he construct a remote-indicating weather vane which can be mounted on the school roof (see chapter 3 of *A Sourcebook for the Physical Sciences*).

CHAPTER 12: WEATHER BY THE SEASON

(text pages 243-55)

• CONCEPTS AND KEY ACTIVITIES

1. *The slant of its axis as the earth revolves around the sun causes our seasons; the length of days and nights changes with the seasons.*

One approach is to have pupils recall some concepts or generalizations from Unit 3 (Exploring the Earth and Space). Review rotation and revolution, using a slate globe (or a regular globe). Use a lamp setup (similar to that on text page 152) with the globe held so that the axis is at a *right angle* to the plane of the earth's orbit. (A convenient device to hold the globe in a path around the lamp is a wooden arm which swivels in a circular path around the light source. To make it, use a strip of wood 1" × 2" × 24"; the length will vary depending on the size of the globe. Drill a hole at one end of the stick through which a threaded metal tube extension of the lamp socket can be inserted. At the other end drill another hole to which the base of the globe may be attached. A rubber ball the size of a grapefruit can serve as an improvised globe. Run a large darning needle through the "poles" to serve as an axis. Bend one end of a second darning needle at an angle of 23½ degrees; interchange these needles (axes) according to the type of demonstration you wish to show.)

With the axis at a right angle to the plane of the earth's orbit, day and night areas of the rotating globe can be reviewed. After stating that the North Pole of the earth is in total darkness for the full 24-hour period on December 21, ask the class how this may be demonstrated. Have pupils experiment by placing the globe in various positions, bringing out that the globe's axis needs to be slanted 23½ degrees to the plane of the orbit. When the north pole is now tipped farthest away from the lamp (sun), it will be in the shadow, while the south pole will have 24 hours of light. Demonstrate what happens when the globe is tilted sidewise with respect to the lamp. (Light will now fall equally on both poles and on northern and southern hemispheres. These positions mark the equinoxes, the beginning of spring and fall.)

If the class learns slowly, you may wish to clinch the ideas with a modified reading lesson (for review). Text pages 243-46 can be read and the diagram on page 244 discussed. Some teachers find it convenient to list key questions on the board and have pupils summarize in their notebooks after discussion.

Demonstrating the Results of Slanting and Vertical Light Rays. Perform the activity described on text page 248. This may be

modified by having a pupil outline the spot of light on the chalkboard, using yellow or white chalk. Compare the area within each outline. Or you may want to set this up as a group activity. Each group can set a flashlight one foot above a large sheet of graph paper; then, at the same height, it can direct the flashlight beam on another sheet of graph paper at an angle. Compare the intensity of light making a circle with that of the light making the elliptical spot. Emphasize that winter sunlight hits the earth at a greater slant than does summer light. Also, the rays pass through more of the earth's atmosphere when they come in on a slant.

Constructing a Simple Sundial. Insert a pencil into a mound of modeling clay placed inside a scaled circle drawn on paper. The pencil should point north and be at an angle corresponding to the degree of latitude for your geographical location (check with a map to determine your degree of latitude). Ask the class to devise a problem that may be solved with the sundial.

Readings. Zim's *Lightning and Thunder* will furnish additional data and many illustrations to supplement the text. A brief but excellent discussion of lightning is on pages 99-100 of *Weather* (a Golden Nature Guide). The attraction of unlike electrical charges within a thundercloud or between the cloud and the earth is revealed in simple diagrams which pupils might enlarge for the bulletin board. Pupils can draw up a list of safety practices with reference to lightning.

Film. One way to review the concept is to show the filmstrip *The Seasons*, which explains the cause of seasons.

HELPING THE SLOW LEARNER

Why not use a supervised reading activity to give more practice in learning to read for meaning? For example, have these pupils read on text page 245 the two paragraphs under "The March of the Seasons." You may wish to motivate this activity by demonstrating the simple planetarium on Manual page 82. Ask pupils to write the main thought of the section, referring to the model if they wish, and then go on to the next section describing the solstices. Be sure to help improvement of meaning by discussion of the written statements of the main thought of each paragraph or section.

2. *In the temperate zone, each season has its own brand of weather; living things react to seasonal weather in various ways.*

You can develop this concept by discovering more about the interests of individual pupils. Ask them to name the season they like best and give reasons for their choice. On the board rule

four columns headed by the names of the seasons. As a characteristic of a season is stated, place this information in the proper column if there is agreement. Point out that climatic characteristics in a large given region vary. How does altitude play a part in climatic variation? Examples may be cited by pupils, based on their reading or actual contact with such an area. (Example: The summer climate of Death Valley is quite different from the summer climate associated with Mt. Whitney and other parts of the Sierra Nevada range, just a relatively short distance to the west.)

Readings. An outgrowth of the description of autumn (text pages 250-51) is a report some pupils may make on chapters from *The Sea Around Us* by Rachel Carson. Suggest they read chapter 12, "The Global Thermostat" (the ocean is the great regulator, or stabilizer of temperatures). The chief advantage of this assignment is that pupils may browse through other delightful chapters in this book.

For the Bulletin Board. The class can assemble pictures from various magazines (such as *Life*) showing how animals and plants adapt to extremes of weather. *The World We Live In* has excellent pictures; you may send to *Life* Magazine for a reprint of any of the sections (20¢ each).

Another type of bulletin board exhibit can be headed: "How we react to seasonal weather." Pupil suggestions will include illustrations of clothing, indoor weather-conditioning systems, and heating systems, insulation in houses, etc. (Groundwork for the next chapter.)

HELPING THE SLOW LEARNER

The slow learner can contribute to class discussion by climate research: Construct large outlines of the U.S. on which are indicated such data as average temperatures, precipitation, number of clear days, and when you can safely plant a garden. Use various colors and a key to show regions. Information can be obtained from a geography atlas, encyclopedia, or *Weather*, pages 147-53. Use a separate map for each set of data.

HELPING THE RAPID LEARNER

Encourage reading research in microclimates, which are local climatic conditions different from the general climate (geographical, biological, and man-made factors can alter the general climate associated with a given latitude). For example, large inland bodies of water moderate temperature extremes; plants cause differences in climate conditions by their use of water and effect on winds. The rapid learner in California, for example, can read about the various life zones based on different climatic conditions caused by altitude

factors. Consult the *National Geographic* for articles and photographs. *Climates in Miniature* (see bibliography on Manual page 112) will prove helpful.

The rapid learner can construct a large, colorful chart to illustrate flora and fauna found at different altitudes within a given latitude. This chart can include information that rising air cools automatically about 5½° F. for each 1,000 feet it rises. (See page 39 of *Weather*. Pages 477-503 in *Climate and Man* describe the effect of climate on forests, plant diseases, and insects.)

Have the rapid learner write to the Superintendent of Documents, Washington, D.C., to obtain *The Average Monthly Weather Resume and Outlook* of the U.S. Weather Bureau. This contains a graphic presentation of the preceding month's weather and an estimate of expected rainfall and temperature for the next thirty days.

He may try some original research: a study of microclimatic differences between his rural or suburban community and a nearby city (or vice versa). Include data on haze, smog, temperature, wind speed and direction, and the factors which caused these differences. Summarize on charts, graphs, etc.

CHAPTER 13: PROTECTING YOURSELF AGAINST THE WEATHER (text pages 256-73)

• CONCEPTS AND KEY ACTIVITIES

1. *The right kinds of clothing and housing give us protection against weather extremes; the proper construction and provisions for heating or cooling the home make indoor living comfortable.*

Show pictures of people who live in different climates; also, high-altitude flyers, campers, or industrial workers who work under extremes of heat or cold. Ask pupils to explain how a particular garment serves its purpose. Then discuss the pupils' proper choice of clothing for varying conditions.

Also, have pupils study methods of heating homes and schools. A planning committee can assemble a list of subproblems, asking for assistance, if necessary. You may use the text (pages 259-66), arrange for a field trip to examine a house under construction or the school itself, or construct models and charts of heating systems.

Pupils can report on advantages and disadvantages of a given heating system.

Demonstrating Characteristics of Clothing Materials. Pupils working in groups can perform the activities suggested on text pages 257-58. Hand magnifiers can substitute for a compound microscope, if necessary. After study of temperature effects produced by sunlight hitting dark and white clothing, pupils can be asked to suggest additional demonstrations for measuring the effect of sunlight on black and white (reflective) surfaces (e.g., use black-and-white-painted glass flasks and one-hole rubber stoppers into which thermometers have been inserted). Have pupils make generalizations from their experiments or reading. Are fashion styles necessarily conducive to health? Pupils can collect examples.

Field Trip. List on the board pupil questions (the nature of the furnace, fuel, and insulation, safety precautions which the custodian takes, diagrams showing the location of the pipes) which may make a visit to the school heating plant more effective. How can the temperature of each room be controlled?

For the Bulletin Board. Pupil diagrams of different heating systems can be posted. Photographs of heating units from last year's mail order catalogue are useful (electric and gas heaters; also, furnaces of different types).

Demonstrating How Heat Travels. Before radiation, convection, and conduction can be illustrated and understood, it is important that pupils comprehend the meaning of heat transfer or exchange.

Place two yardsticks side by side, about one-half inch apart, and slightly inclined. Hold a rubber ball at the top of the incline and ask in what direction it will go when you release it. Explain that the rubber ball represents an amount of heat; the heat will flow from a point of higher temperature to a point of lower temperature (from a point having a high energy level to a point having a lower energy level). During discussion some pupils may express curiosity as to the difference in meaning between heat and temperature. Elicit as many opinions as possible: How do you go about heating water? How do you obtain its temperature?

Demonstrating the Difference Between Heat and Temperature. Boil a quantity of water in a 500-cc. Pyrex beaker (or a metal container such as a can or pot); boil a smaller quantity of water in a 50-cc. beaker. When the water is boiling, extinguish the flame and have pupils read the temperature for each container. The same thermometer reading for the water in both beakers tells us that the degree of molecular motion is the same. There is more heat energy in the larger beaker of water (related to the fact that there is a larger quantity of matter). How would the heat energy levels compare if two 50-cc. beakers, each containing 25 cc. of

water, were heated to the boiling point? Place a diagram on the board to emphasize that equal quantities of matter are involved. A large amount of boiling water at 100° C. may contain much more heat than a very small quantity of melted iron at $1,700^{\circ}$ C. Demonstrate heat transfer from cold water to colder dry ice: Drop a piece of dry ice into a beaker of water. A furious boiling results as heat in the cold water is transferred to the frozen carbon dioxide (dry ice), causing it to return to vapor state.

Demonstrating Convection Currents. Place some sawdust in a beaker of water and apply heat at one edge; note that the water in closer contact with the heat source rises, the cooler water sinks. Discuss the flow of convection currents in the room.

Demonstrating Conduction of Heat. Hand a nail to a pupil and ask him to heat it in the flame of an alcohol or gas burner. Why did the pupil drop the nail quickly? Bring out that the molecules in the end of the nail, when heated, move very rapidly and bombard the nail molecules nearby, causing them to move faster. (Heat is the energy of motion of molecules.)

Model of a Steam Heating System. If pupils are to construct the model shown on text page 262, use Pyrex Erlenmeyer flasks (250 cc. or ml.). The glass tubing should be fire-polished to remove sharp edges (heat the ends until they just glow red); use a one-hole stopper made of fresh rubber.

Demonstrating the Effect of an Insulator. Use two empty tin cans of the same size, wrapping one with pieces of an old woolen sweater, asbestos, or some other poor conductor of heat. Pour equal quantities of boiling water into each can and take a simultaneous reading with separate thermometers. The air in the insulating material is a poor conductor of heat (since in a gas the molecules are farther apart, there is less chance for them to hit each other and therefore less opportunity for them to pass their energy of motion, heat, from one to another as easily as molecules of a liquid or solid do.) This explanation may be understood by the rapid learner and arouse his curiosity enough to devise additional demonstrations.

Demonstrating Home Insulation Materials. Ask a building supplies store (or a contractor) to donate or lend samples of rock wool, glass wool, asbestos, etc. Perhaps the class can suggest ways of testing the insulating efficiency of each material. (Use the technique of the two cans mentioned in the previous activity.)

Films. *Heat—Its Nature and Transfer* can be used to review the principles of conduction, convection, and radiation. A more advanced film, *Learning About Heat*, discusses the properties and characteristics of heat transfer.

HELPING THE SLOW LEARNER

Have the slow learner study the diagrams on text page 265. He can assemble a collection of insulated objects or their photographs (woolen gloves, Thermos flasks, pot holders, wooden handles on pots, etc.). Explain the usefulness of each.

He can do simple experiments involving heat transfer. There are many good ideas in some of the books listed on Manual page 215, such as the booklet *Heat*, by Bertha Parker.

2. *Safety from fire depends on awareness and correction of hazards*.

Start by heating some water in a paper cup. Pupils may express surprise that the paper does not ignite; ask for reasons. (The water removes the heat from the paper cup so quickly that the kindling temperature is not reached.) Why do firemen wet down the wooden walls of a building adjacent to a fire?

Field Trips. Arrange with a contractor or supervisor to allow your class (or a committee) to visit the site of a building under construction. Plan to go during the workers' lunch hour or after they have left. Look for evidences of fire protection.

Observe the types of fire extinguishers on fire trucks on a field trip to a fire station. Pupils can list materials used to put out fires; discuss such concepts as water pressure, kindling temperatures, oxygen, fuels illustrated by these items. Invite the fire safety officer to talk to the class.

Inspection of Home Fire Hazards. Have pupils draw up a fire safety check list after inspecting their own homes. This list may be printed either in the science newsletter or as a check sheet for the school. Suggest that pupils discuss with their parents any hazards noted on their inspection tour.

For the Bulletin Board. Assemble news clippings of fires in your community and elsewhere. How might each have been prevented? Place captions over some of the clippings which call for pupil comment.

Films. You might introduce the concept with *How to Fight a Fire in the Kitchen*, available on free loan. Some fire departments, as part of their safety program, will lend similar films; some may supply a projectionist and illustrative materials.

HELPING THE SLOW LEARNER

The slow learner may be quite adept in other fields. If he enjoys camping, for example, have him demonstrate the correct way of building and extinguishing a fire. He might be permitted

to do this in a corner of the school playground. Why is it a poor practice to throw water into an outdoor fireplace, such as those in state parks? Pupils may try to solve this question by heating a piece of soft glass tubing and thrusting it quickly into a beaker of cold water.

HELPING THE RAPID LEARNER

The rapid learner may delve into the problem of refrigeration. A class set of booklets, *The A to Z of Refrigeration*, can be obtained from the General Motors Corporation.

He can make an original study of the causes of fires in his community, accompanied by graphs and photographs, obtaining his data by personal interview with the fire chief.

If the P.T.A. has a Safety Committee, why not suggest a pupil liaison committee to meet with them, at times, to discuss fire safety precautions. The bright pupil can act as leader in organizing the group and arranging an agenda.

SUMMARY AND USE OF TESTS

Tremendous advances in techniques of weather forecasting have been made during the last twenty-five years. Increased accuracy in forecasting is based on electronic devices such as radar, used in tracking such phenomena as hurricanes and tornadoes. Weather satellites may be of great importance in understanding global weather.

You may wish to make use of the *Harbrace Teaching Tests* to accompany *You and Science*, Forms A and B. Each booklet contains objective-type tests for each chapter and a unit test.

BIBLIOGRAPHY FOR STUDENTS

1. *A to Z of Refrigeration*, General Motors Corp. Free booklet, contains colored diagrams.
2. Barnett, L., *The World We Live In*, Simon and Schuster, 1956.
3. Bedford, F. T., *Climates in Miniature*, Philosophical Library, 1955. A nontechnical study of microclimates and environment.
4. Brinckerhoff, R., and others, *The Physical World*, Harcourt, Brace, 1958. Contains many clear diagrams and photographs; easy to understand.
5. Carson, R., *The Sea Around Us*, Mentor, 1954.
6. Kaplan, J., "How Man-made Satellites Can Affect Our Lives," *National Geographic*, December, 1957.
7. Krick, I., and R. Fleming, *Sun, Sea, and Sky*, Lippincott, 1954.
8. Lehr, P. E., R. W. Burnett and H. S. Zim, *Weather*, a Golden Nature Guide, Simon and Schuster, 1957. Excellent reference for diagrams about weather.

9. *Little Climates*, Cornell Rural School Leaflet 3, Vol. 37, January 1944.
10. Marshack, A., *The World in Space*, Dell, 1958.
11. Schneider, H., *Everyday Weather and How It Works*, Whittlesey, 1951.
12. Spilhaus, A., *Weathercraft*, Viking, 1951.
13. *Weather Wise*, American Meteorological Society, 3 Joy St., Boston 8, Mass. Nontechnical, bimonthly weather magazine.
14. Zim, H. S., *Lightning and Thunder*, Morrow, 1952.

BIBLIOGRAPHY FOR TEACHERS

1. *Climate and Man*, 1941 Yearbook of Agriculture, U.S. Department of Agriculture, Washington, D.C.
2. Joseph, A., P. F. Brandwein, and E. Morholt, *A Sourcebook for the Physical Sciences*, Harcourt, Brace, 1959.
3. *Manual of Cloud Forms and Codes for the States of the Sky*. Has many photographs of clouds. Also, *The Average Monthly Weather Resume and Outlook*, U.S. Weather Bureau, Superintendent of Documents, Washington, D.C.
4. Wexler, H., "The Circulation of the Atmosphere," *The Planet Earth* (Scientific American book), Simon and Schuster, 1957.

UNIT 5

Investigating the Earth's Storehouse

GENERAL THEME: *As we learn more about the structure of matter, we are able to make better use of the raw materials in the earth, to refine them, and to get new products from them.*

The student examines the structure of matter in order to understand how the raw materials in the earth can be used. This study includes an elementary understanding of atoms, elements, compounds, and mixtures (text pages 276-86), and of minerals and ores (pages 315-18). The student learns how scientists discovered the composition of atoms, the basic building blocks of matter. He sees how atoms of some radioactive elements can be made to undergo fission (pages 282-99). He learns how scientists built the first atomic bomb and the effects of an atomic bomb explosion. He realizes how atomic fusion of hydrogen into helium was responsible for the explosion of the first hydrogen bomb (pages 300-04). Then he sees the present peacetime uses of atomic energy and its opportunities for the future (pages 304-12). Further to enlighten him on the commercial and peacetime developments of atomic energy, he is provided with charts and photographs in full color at text page 288.

The pupil examines the wealth in the earth's crust by observing the more common chemicals he uses every day, from salts dissolved in water to gases making up air (pages 315-25). He also studies how ores are mined and how steel and alloys are made. He studies the uses of coal, oil, sulfur, salt, limestone, clay, and sand (pages 332-38). At the same time he learns what is being done to conserve our mineral resources (pages 338-42). Finally, to give him an idea of how scientists work in these and other ways, he is introduced to a hobby, chemistry at home (pages 346-49).

The Unit Inventory. Before commencing study of this unit, you will find it helpful to have the pupils test themselves on what they know of the general theme of investigating the earth's storehouse (text page 274). Thus you will be able to discover background information known by the pupils and plan your time allotment to stress specific topics and supporting activities.

PLANNING AHEAD

So that you may plan ahead for a particular film, equipment mentioned in this Manual, or a special program, the following items are listed in the order mention is made of them in the unit. A more complete list of films, arranged by topics, appears on Manual page 202.

FILMS AND FILMSTRIPS

f = film   c = color   fs = filmstrip

Chapter 14

1. *A for Atom* (f,c), General Electric, 1953, free loan.
2. *Matter and Energy* (f,c), Coronet, 1947.

Chapter 15

1. *Atomic Energy* (f), AEC, free loan.
2. *Atoms as You Will Use Them* (fs,c), Harbrace.
3. *Unlocking the Atom* (f), AEC, free loan.

Chapter 16

1. *Carbon and Its Compounds* (f), Coronet, 1949.
2. *Water* (fs), Soc. for Visual Ed., 1948.

Chapter 17

1. *Oil: From Earth to You* (fs), Am. Petroleum Inst., 1952, free copy to each school.
2. *Petroleum in Today's Living* (fs), Am. Petroleum Inst., free.

EQUIPMENT FOR DEMONSTRATION AND EXPERIMENT

Chapter 14

sponge, rubbing alcohol, modeling clay, manganese dioxide, teaspoon, 3% hydrogen peroxide, wood splints, chemical balance, 2 beakers (100 ml.), baking soda, vinegar, pail or aquarium tank, candle, fresh yeast cake, molasses, one-hole rubber stopper, test tubes, glass tubing, colored chalk, dried green peas, marbles, wire (rigid), red goggles, wrist watch with luminous dial

Chapter 15

photographs or slides of atomic blast, H-bomb blast photographs, Geiger counter, pictures of atomic submarines, reactors

Chapter 16

mineral collection, glass slides, medicine droppers, photographs of water scale on pipes, soap solution, Epsom salts, distilled water, calcium carbonate, 12" large glass tube (20-30 mm. in diameter), 2 two-hole rubber stoppers to fit 5 mm. (outside diameter) glass tubing, triangular file, rubber tubing to fit 5 mm. glass tubing, limewater, photographs of oxygen equipment

samples of ores and metals, metal strips of copper, zinc, tin, aluminum, lead, cadmium, paraffin, two 1½-volt dry cells, small light bulb, wires, solder, lead, tin, sodium carbonate, Wood's metal, one dozen 12-penny nails (6 plain, 6 galvanized), sandpaper, light oil, coal samples

FIELD TRIPS TO BE ARRANGED

Visit of pupil committee to local hospital laboratory, and visit to local metallurgical plant.

ATOMIC ENERGY CHARTS

Between text pages 288 and 289 is an eight-page full-color section on atomic energy. You may wish to preview this section with students before you begin the unit in order to get students into the habit of referring to this section as they study the units, particularly Chapter 15. The diagrams of the nuclear power plant are based on the Shippingport, Pennsylvania, reactor. Encourage your students to start gathering clippings illustrating recent developments in atomic energy and uses of the products of atomic energy.

CHAPTER 14: ATOMS—BUILDING BLOCKS OF THE UNIVERSE (text pages 276-89)

• CONCEPTS AND KEY ACTIVITIES

1. *Matter may exist as a solid, liquid, or gas.*

2. *An element is composed of similar atoms.*

3. *Most forms of matter found on earth are mixtures of compounds and elements.*

4. *A molecule of a* substance *is the smallest part which still shows the properties of the substance; it is composed of atoms of either similar or different types.*

One way to start is to streak the chalkboard with a dampened sponge. As it evaporates, ask the class why the water has become invisible. Use the same procedure with alcohol. Lead into a

discussion of molecules, once the term is mentioned by a pupil. Ask other pupils to give as many ideas about molecules as they know; list on the board. Elicit the idea that molecules are in motion. Streak some alcohol on the palm of a pupil's hand. Have him describe the effect and review the idea that heat is removed from a surface when liquids evaporate, thereby changing to a gas.

Review the liquid, solid, and gaseous states of water (water, ice, water vapor). In what state would you expect water molecules to move most rapidly? Explain. Vary your questions so that the slow learner may respond to "Can you suggest how the solid state of water can be changed to the liquid form?" Ask the moderate learner, "Can you think of a way to bring invisible water vapor, a gas, to the liquid state?" (Condense on a cold surface.) Lead into atoms from molecules.

Building a Collection of Common Elements. Ask pupils to bring in samples of elements. Develop the idea that an element is composed of its own kind of atoms. What is the smallest part of the element hydrogen? Pupils may assemble copper, zinc, carbon (charcoal), aluminum, sulfur, iron, lead, etc. Several large charts can be made to picture such information as chemical symbol and characteristics of the element. The smallest part of an *element* that still shows the properties of the element is an atom.

Constructing a Model of a Water Molecule. You may wish to demonstrate the electrolysis of water (see text pages 280-81). Prepare "atoms" of hydrogen and oxygen (different-colored balls of modeling clay). After discussion, have pupils join these clay balls to produce a "molecule" of two "hydrogen atoms" and a larger clay "oxygen atom." Pupils can explain the significance of the symbols "H_2O"; also "CO_2" for carbon dioxide.

Demonstrating Chemical and Physical Changes. Tear a sheet of paper into pieces. Then, without comment, burn them. Ask, "Which is a chemical change? Which is a physical change? Under what conditions were the chemical properties of the paper changed?"

Laboratory Preparation of Oxygen. The properties of an invisible gas, oxygen, can be studied by pupils working in pairs. In a standard test tube place a small amount of manganese dioxide (¼ to ½ teaspoon) into 1 to 2 ounces of 3% hydrogen peroxide. This activity can be performed with limited facilities. Thrust a glowing splint into the mouth of the tube. Ask the pupils to explain why the glowing splint bursts into flame. What chemical changes took place in the wood? Elicit that new compounds such as carbon dioxide and water were formed as the wood combined with oxygen. Discuss uses of pure oxygen in industry and aviation.

Demonstrating the Preparation of Carbon Dioxide. Carefully weigh a glass or beaker on a sensitive balance. Hold up another

beaker of the same size and tell the pupils that you are going to use it to pour carbon dioxide into the beaker on the balance. Now empty the contents of a box of household baking soda into a large pail (or empty aquarium tank) and pour vinegar onto the baking soda until the fizzing stops. Ask what causes the fizzing.

Then dip the other beaker sidewise into the pail close to the bottom, turn it right side up, and slowly lift it from the pail. Now pour the invisible contents (carbon dioxide) into the beaker on the balance. Ask why the beaker on the balance is now heavier than before. Discuss the fact that all gases have weight.

Pour another beakerful of carbon dioxide over a lighted candle. Discuss the use of CO_2 fire extinguishers.

Films. *Matter and Energy*, a Coronet film in color, is good for review of the forms of matter and of elements, compounds, and mixtures.

HELPING THE SLOW LEARNER

Obtain a copy of *Our Friend the Atom*, by Heinz Haber, which is profusely illustrated. Pages 22-40 discuss simple ideas about molecules and atoms.

The slow learner may want to supplement the demonstration of CO_2 preparation by collecting the gas produced when yeast acts on molasses (glucose). Break a quarter cake of fresh yeast into a test tube half-filled with 50% molasses-water solution. Place a glass delivery tube in a one-hole stopper, insert in the test tube, and collect the gas in an inverted test tube filled with water. The CO_2 will displace the water. Or the pupil may bubble the gas through lime water.

5. *An atom contains a nucleus with one or more electrons revolving about it.*

6. *Neutrons and protons are particles of matter found in the nucleus of an atom.*

Develop the idea of an orbit (path) by reviewing the movement of the planets around the sun or the path of artificial satellites around the earth. Ask whether any pupils can think of an extremely minute "solar system." This may call for some pupil research (or turn to text page 286 and study the diagrams). Then continue into the concept; you may wish to develop a historical sequence through pupil reports on Dalton and Rutherford.

Constructing Models of Atoms. Research on atoms can culminate in clay models. (They can be displayed, accompanied by appropriate charts.)

Modeling clay may be used to hold dried green peas (protons) and marbles (neutrons) together to make up a nucleus; or clay balls of different colors can be pressed against each other. Orbits can be made from wire clotheshangers; impale clay balls on them to simulate electrons. These models may be used later for a discussion of isotopes. (If you live in an area where the sweet gum tree, *Liquidambar*, grows, have pupils collect the spiny fruiting bodies that fall to the ground. Dye the fruits various colors. A model of protons and neutrons for a specific atom can be assembled quickly.) Later, in discussing nuclear changes, you can show neutron losses with equal ease.

Demonstrating Atomic Breakdown. Light flashes in a luminous watch dial indicate disintegration of radium in the paint used. Place the watch on the stage of a microscope in a very dark room. A pupil or a group of several pupils may be permitted to set up this demonstration and report on it. The observer should be dark-adapted (in a dark room for 30 minutes, or having worn a pair of red goggles for the same time in a lighted room). The flashes of light occur when radiations from the radium strike the zinc sulfide in the paint, producing a glow.

Films. The first part of *A for Atom*, a free film, can be used for review of parts of the atom.

HELPING THE SLOW LEARNER

Encourage the slow learner to construct simple clay-and-wire models of atoms of hydrogen, helium, and oxygen. Comic books on the atom are available free (specify how many you need) from the General Electric Company. Portions of these booklets are helpful in reading activities. The book *All About the Atom* has a readable section on basic ideas. "Atoms at Work" (pages 54-69) presents simple line drawings and simplified text dealing with "inside the atom."

HELPING THE RAPID LEARNER

The science-prone student who likes to delve into the background of a topic can find more about Dalton's work on pages 220-50, Vol. 1, of the *Harvard Case Histories in Experimental Science*. Or he may be encouraged to read an account of the life of Madame Curie or Lord Rutherford.

He can read about a cloud chamber, a device to detect tracks atomic particles make; and he can even build one. Consult a college text book, or see text page 289.

CHAPTER 15: SPLITTING THE ATOM
(see pages 290-314)

• CONCEPTS AND KEY ACTIVITIES

1. *Man is now able to change the structure of some atoms.*

2. *Part of a splitting atom (through fission) turns into energy; a huge amount of energy is given off in a chain reaction.*

3. *An atomic pile (or nuclear reactor) can control chain reactions, resulting in release of tremendous amounts of heat energy that can be harnessed usefully.*

The approaches to these concepts are many. If you have not previewed with your students the full-color charts of Atomic Energy between text pages 288 and 289, a good time to do so is before starting study of this chapter. Or you may use the charts concurrently or as a review.

Photographs or slides of atomic bomb explosions and pictures of atomic energy for peacetime uses are readily available. Collect them to supplement the full-color atomic energy charts. A discussion of the effects of atomic energy on mankind will draw out some pupils who might otherwise be silent. They can help list on the board the problems and questions brought up in discussion. Stress that all citizens should be aware of the tremendous potential of atomic fission and fusion. You might want to set up some pupil research assignments.

Collecting Free Material on Atomic Energy. On school stationery write for free literature and photographs from the Atomic Energy Commission, Washington, D.C., or Oak Ridge, Tennessee. Your classroom collection will provide an atmosphere for investigation. Encourage pupils to "check out" booklets for class or home reading. Several additional sources of free materials are listed on Manual page 131.

Demonstrating Chain Reaction. Some pupils may be familiar with the "chain letter." Or suggest the analogy of the forest fire which spreads rapidly from one spot. Then ask two pupils to help you prepare an analogy, using marbles. Set up several bunches of marbles fairly close together. In each bunch (nucleus) are dark (neutrons) and light marbles (protons). "Explode" a nucleus by having one pupil hit one bunch of marbles with a "neutron bullet." The nucleus hit by the neutron will undergo "fission," and some of the particles (marbles) will hit another nucleus, exploding it in turn. You may wish to point out, however,

that in practice only a neutron can explode a nucleus and that a nucleus usually splits in two, as in Atomic Energy Chart 1 at page 288.

Building a Model of an Atomic Pile. The concept of an atomic pile (or nuclear reactor) can be taught effectively by allowing opportunity for investigation. As pupils look up details (for the model), they will pick up ideas which can be reported to the class. They may use plywood or cardboard for the concrete shielding, black painted wood for the graphite, metal rods for the control rods, and small metal slugs for the uranium. See the atomic energy charts at page 288, text pages 298-99, or pages 111-14 of *The Physical World* for drawings of different reactors or atomic piles.

Films. The Harbrace filmstrip *Atoms as You Will Use Them* will enable your class to visualize better the parts of an atom and the idea of fission. Parts of the filmstrip will help clarify certain ideas. (For example, frame 15 discusses the reasons for the use of a neutron as an atomic bullet, rather than a proton or electron which has electrical charges. Electrons are too light to split a nucleus; slow protons are repelled by the positively charged nucleus, while the heavier neutrons are not repelled and can easily enter the nucleus at *slow* speeds.) The filmstrip can also be used as review. Some science-prone pupils may wish to use some of the frames in their reports. See list of additional films on Manual page 115.

For the Bulletin Board. Assign a committee to keep an up-to-date series of clippings and printed captions on new advances in atomic energy.

HELPING THE SLOW LEARNER

The slow learner will enjoy (and so will other class members) the simplified text of chapter 8, "The Nucleus Goes to Work," in *Atoms at Work*. Also, *Atoms Today and Tomorrow*, chapters 2-6, have lucid presentations on atom smashing and the atomic pile.

The General Electric free comic books on atomic energy, such as *Adventures Inside the Atom*, can be obtained in quantity for class discussion. The pictures can be "read" effectively with the simple story-book text (slow readers, especially, will like this change-of-pace approach in your teaching).

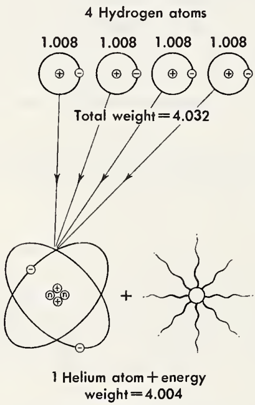
4. *The uniting of hydrogen atoms to form helium is an example of atomic fusion; as in atomic fission, matter is changed into energy.*

5. *Atomic energy has many peacetime uses in industry, agriculture, and medicine.*

Show photographs or slides of a hydrogen bomb explosion and draw comments with regard to comparisons with atomic bomb blasts. An enlargement of the chart on text page 303 can be used.

Bring out that the sun and other stars are fusing hydrogen atoms continually. Develop the idea of man-made atomic fusion, through information from short pupil reports, as well as text pages 302-03. Some pupils may ask about the lithium or L-bomb. This may be the basis for additional reading or you may want to diagram some simple steps on the board and ask the class to make comparisons with the hydrogen bomb:

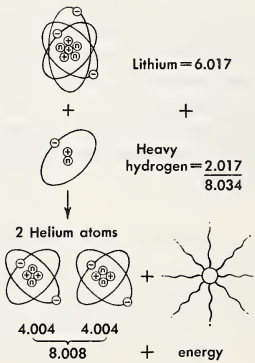
HYDROGEN BOMB



Weight loss = 0.028 changed to atomic energy

Note that during fusion to form an atom of helium, weight is lost. The lost matter is released as atomic energy.

LITHIUM BOMB



Weight loss = 0.026 changed to atomic energy

The combined weight resulting from fusion (8.008) is less than the original weights of the fusing atoms. The lost matter is released as atomic energy.

You may wish to review the idea of "critical mass" (text page 300) before comparing further the similarities and differences

between fission and fusion. For example, uranium 235 is kept in quantities smaller than those needed to start a chain reaction. Explain that not enough uranium atom targets are exposed when the mass of uranium is below a certain size. Bringing quantities of uranium 235 closer together increases the target area. In other words, in fission only a relatively small amount of energy needs to be available for absorption by this certain size (critical mass) of U 235, in order that a chain reaction may start.

Review that in *fusion* a tremendous amount of energy must be released in a concentrated unit of time to bring about the high temperature and pressure needed to trigger the reaction. There is no limit to the size of a hydrogen bomb; critical mass limits the size of the A-bomb.

Films and Filmstrips. There is a good description of fusion and fission in *Atoms as You Will Use Them*. It is also excellent for introducing discussion on peaceful uses of atoms (radioactive tracers or isotopes). *Unlocking the Atom* is a free film from the AEC which describes atomic structure, cyclotrons, chain reactions, and radiation. *Atomic Energy*, from the same free source, discusses basic principles including fission and chain reaction.

For the Bulletin Board. Assemble pictures which show uses of atomic energy. Pupils can compose a key question for each diagram or photograph. For free material write to three of the sources (General Electric, Westinghouse, and the Atomic Energy Commission) listed on Manual pages 223-25.

Field Trip. Arrange, if possible, a visit with a pupil committee to the local hospital to see some of the laboratory equipment used in working with radioactive isotopes. Pupils can prepare reports on preparation of radioactive atoms.

Panel Discussion. A topic such as "How Do We Use Atomic Energy" can be a broad review of the subject. Members of the panel should present aspects such as beneficial uses and harmful possibilities, illustrating their remarks by reference either to the Harbrace filmstrip or to charts and pictures prepared in advance.

Exhibit of Atomic Energy Uses. Committees can assemble materials for display. Obtain publicity through the school newspaper. Borrow a Geiger counter and present demonstrations at announced times.

Readings. The late Selig Hecht's *Explaining the Atom* is easy reading for most average pupils. *Atoms Today and Tomorrow*, chapters 7-11, covers the uses of "tagged" atoms in science and industry. If your school has access to a Geiger counter, you may demonstrate some of the simpler experiments in *Laboratory Experiments with Radioisotopes for High School Science Demonstration.* You may obtain a free class set of *The Atom in Our Hands*, a booklet on applications of atomic energy in industry.

HELPING THE SLOW LEARNER

As we have mentioned previously, illustrated readings such as *Adventures Inside the Atom* (comic book) and *Our Friend the Atom* (pages 133-58) show colored diagrams of atomic reactors, an atomic submarine, and radiation use in medicine.

Suggest that the slow learner assemble news clippings and photographs of atomic submarines going on long cruises. Utilize text page 307 to describe the reactor in a submarine. He may make an enlarged drawing in color. Ask him to compose questions on which he would like comment.

HELPING THE RAPID LEARNER

Suggest that the rapid learner read, if interested, chapter 4, "Careers in Atomic Energy," in *Your Career in Physics*. He can compose a chart of vocations which employ nuclear scientists.

If the school has a Geiger counter the rapid learner may help you put on a demonstration. For instance, radiations from a luminous watch dial can be detected (have another pupil hide the watch in his pocket). Or he can build a model of an atomic pile and explain the actions.

Have him write (on school stationery with your endorsement) to Oak Ridge, Tennessee, and ask the AEC for copies of radioisotope exhibits. Or he can build models of stable and unstable (radioactive) iodine and phosphorus atoms (see drawings on page 128 of *The Physical World*).

CHAPTER 16: COMMON CHEMICALS AROUND YOU (text pages 315-27)

• CONCEPTS AND KEY ACTIVITIES

1. *The chemical elements about us have many uses; elements are often found together in minerals and ores.*

Approach this concept by asking the class to suggest common chemicals they used at home just before coming to school. List these on the board as they are named. Elicit the names of the elements in such compounds as table salt, sugar, water, fats (found in butter), protein (found in lean meat, egg-white), etc. You may want to list the chemical symbol for each element in a different color chalk (see Table 10 on text page 317). Or you may

assign committees to investigate the composition of the compounds listed on the board and submit their data later in the period.

For the Bulletin Board. Under such headings as "Chemicals used at home" or "Chemicals we use at school," assemble pictures of materials which contain useful chemical compounds.

Assembling a Collection of Chemicals. Using Table 10 (page 317), ask your pupils to bring in samples of minerals and ores in the neighborhood. Some students may already have collections. The other pupils can look up information about the chemicals (elements) which comprise these minerals. Include a list of elements which can occur free in nature (such as oxygen, carbon in coal or graphite, gold, nitrogen, silver, and sulfur).

Ask the class to develop ideas for the display of such gases as oxygen, hydrogen, and carbon dioxide. This project can include a review of concepts already studied.

Film. *Carbon and Its Compounds*, a Coronet film, can be shown and referred to later when coal is discussed.

HELPING THE SLOW LEARNER

The slow learner can read *Its Fun to Know Why: Experiments with Things Around Us*, and try some of the simple activities. Common materials such as iron, coal, glass, paper, and wool can be used. Also, *Invitation to Experiment* contains some simple ideas on how to use apparatus and chemicals.

HELPING THE RAPID LEARNER

Some of the suggestions on text pages 346-49 can be tried by the science-prone child as an optional homework assignment.

2. *Water is a chemical compound needed by living things; water tends to hold many chemicals in solution.*

3. *Air contains a number of gaseous elements.*

Ask the class to explain why a person doing exercise needs water sooner than he needs food. Have pupils cite personal experiences. Do plants need water? Explain. And then go into the concepts.

Demonstrating That Water Holds Dissolved Materials. If some sea water is available, weigh 100 grams into a beaker, and gently boil over a hot plate or gas burner. When the water has disappeared, note the residue. When the beaker has cooled, weigh the beaker with its sediment (about $3\frac{1}{2}$ grams of salt is present). If no sea water is available, add $3\frac{1}{2}$ grams of table salt

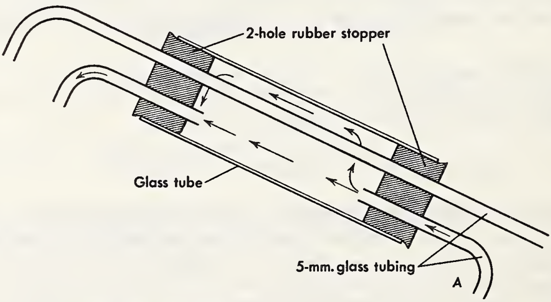
to 96½ grams of distilled water. Of course, there are other types of salts in sea water, so this can be "analagous" rather than synthetic sea water.

Demonstrating That Tap Water (in Some Areas) Contains Dissolved Materials. Pupils can be asked to observe the sediment which shows up when water in a clean saucer evaporates. (This may be done as a homework assignment.) Or pupils can work in pairs: Distribute glass slides to each pair; allow them to place a drop of tap water on the left side of the slide, and a drop of distilled water on the right side. Compare the two dry areas after evaporation has taken place.

For the Bulletin Board. Assemble newspaper clippings relating to minerals dissolved in water. In what communities have fluoride compounds been added to the drinking water? Perhaps literature and photographs of hard water "scale" can be obtained from a water-softener company.

Demonstrating Hard and Soft Water. If your community has hard water, follow the suggestions on text pages 319-20, and allow groups of pupils to test soap solutions made with distilled water, Epsom salt solution, and calcium carbonate solution, in addition to the type of hard water from the tap. Make up various types of salt solutions if your community has soft water. Ask pupils to suggest how they would go about testing different kinds of soaps.

Demonstrating Distillation of Water. If your school lacks the Liebig condenser shown on text page 323, you can improvise one with glass tubing and a large-diameter glass tube closed at both ends with two-hole rubber stoppers. To avoid "air lock," make certain that the water enters the jacket at "A," as indicated in the diagram.



Use fresh rubber stoppers and 5-millimeter (outside diameter) soft glass tubing. This is one millimeter smaller than standard size, but it will prevent difficulties, such as insertion of the glass tubing into the rubber stoppers. It is helpful to moisten both glass and rubber and twist the stopper onto the tube.

Discuss (also with student reports) water distillation survival kits for fliers forced down at sea. List uses for distilled or pure water.

Demonstrating Limestone Formation. Fill a test tube half full of limewater. Call a student to the front of the room and hand him the test tube and a straw. Have him blow carefully into the limewater in the test tube. Why does the limewater turn milky? (The carbon dioxide the pupil breathes out reacts with the limewater to make calcium carbonate, a form of limestone.) Tell the pupil to keep on blowing into the liquid. Why does the milky substance disappear? (The calcium carbonate is dissolved as more carbon dioxide is blown into the liquid, forming soluble calcium bicarbonate as the student continues to blow.)

Now have the pupil (or another one) heat the test tube over a Bunsen burner, using a low flame. Why does the milky color reappear? (When water containing soluble calcium bicarbonate is heated or evaporated, the calcium carbonate is formed again.)

Discuss how limestone caves are formed by underground water containing carbon dioxide. Discuss also how these limestone formations resulted from evaporation of water containing soluble calcium bicarbonate.

Filmstrip. *Water* is a filmstrip which can be used to review the uses and importance of water, formation of water, and water softeners.

Demonstrating Uses of Oxygen. An interesting project consists of assembling photographs and charts of such equipment as oxygen masks, small oxygen tanks (walk-about type), acetylene torches, and oxygen tents. The pupil can demonstrate production of oxygen with the aid of manganese dioxide and 3% hydrogen peroxide (text page 326). Other pupils may construct charts which indicate the gases in air. Discuss the problems of breathing at high altitude.

HELPING THE SLOW LEARNER

The science-shy pupil, after he has tried some of the exercises, can help demonstrate some elementary principles about water. For example, he can demonstrate that living things contain varying amounts of water. Place some green leaves in a dry Pyrex test tube and heat gently. Note the condensed water on the sides of the tube. Use "dry" bread, wood particles, etc.

The slow learner can experiment at home to determine what substances dissolve in water. How would he plan this demonstration? What is the effect of heat in the process of dissolving?

HELPING THE RAPID LEARNER

Water, the 1955 Yearbook of Agriculture, contains many short, excellent articles such as "Conversion of Saline Waters," "Underground Sources of Our Water," and "The Needs and Uses of Water by Plants." This book, and many others on the subject, will permit the rapid learner to deepen his understanding and report his new findings to the class.

If he is interested in chemistry, refer him to the books listed on text page 349. He can improvise many bits of equipment such as the test tube holder shown on page 347. If several pupils develop home chemistry laboratories, why not put on an exhibit with your science-prone pupils as organizers?

CHAPTER 17: THE WEALTH IN THE EARTH'S CRUST (text pages 328-45)

• CONCEPTS AND KEY ACTIVITIES

1. *Man obtains important metals from ores; alloys can be made by melting together different metals.*

One way to start a lesson on metals and alloys is to exhibit materials (sample ores and metals) obtained from a steel company. Write to the advertising departments of Bethlehem Steel, Bethlehem, Pennsylvania; or Youngstown Steel, Youngstown, Ohio; or the various plants of U.S. Steel, or of any steel company in your region. Ask for materials available for schools. If you wish, discuss the relationship of science to industry and the importance of engineering to life. Another good way to get packets of materials relating to science and industry is to join the National Science Teachers Association, 1201 16th Street, N.W., Washington, D.C., which has regular mailings of useful teaching materials.

Ask the class to name the most important or useful metal and give reasons for their choice. List these metals on the board—and continue to develop the concept.

Demonstrating the Physical Properties of Metals. This can be done by a committee, especially if some of the students are familiar with some characteristics of a few metals (based on a previous assignment). Demonstrate luster by sandpapering strips of the various metals (copper, zinc, tin, aluminum, lead, cadmium). Hardness and malleability may be compared and a chart of physical properties prepared for future discussion.

Also, other pupils can test heat conductivity. Ask the class to suggest a way of determining which of several different metal strips is the best heat conductor. (Place small, equal-sized pieces of paraffin at one end of the metal strips, one to each strip. On which metal strip does the wax melt first when the strips are held over a flame?)

Electrical conductivity may be tested by wiring two dry cells in series with a small light bulb (or bell), but leaving a gap in the circuit. Test the metal strips by inserting each into the gap, thus completing the circuit.

Project Reports on the History of Metallurgy of Iron or Aluminum. Suggest that pupils use charts such as the one on text page 331 (blast furnace) to illustrate their presentation.

Field Trip. If you live in a community which contains a metallurgical plant, try to arrange a visit to see the manufacture or processing of metals from their ores.

Demonstrating Alloys. Solder, an alloy of lead and tin, can be made in class, following the directions given on text pages 343-44. Another modification consists of dusting the surface of the lead and tin with sodium carbonate as a flux, and then heating. The combination can then be cooled and the properties of the alloy compared with those of the original metals. Note that the melting point of solder is 220° C., compared with tin (232° C.) and lead (328° C.)

Obtain some Wood's metal (Table 11, text page 332) and place a small amount in a test tube; insert the tube into a beaker of water and heat to a boil. Ask the class to suggest why this alloy is used in automatic sprinklers.

HELPING THE SLOW LEARNER

Suggest the activity dealing with preventing rust (text page 344, item 3). In addition to the nails listed, have the pupil file one half the length of the galvanized nail before placing it in water. Can he suggest any other material to place on some of the ordinary nails to prevent rust?

2. *Valuable minerals such as oil, coal, sulfur, and limestone are obtained from the earth's crust.*

3. *Our mineral resources are being used up rapidly; we need to take active steps to conserve the resources remaining.*

Begin by showing samples of peat, lignite (brown coal), bituminous (soft), and anthracite (hard) coal. You may get the samples

from a local dealer or from the Bituminous Coal Institute, Washington, D.C. Discuss how coal was formed and the different stages in its development.

Elicit from the students how coal is used as a source of energy (heating homes, making electricity, etc.). Discuss the use of coal in making illuminating gas and coal-tar products. Use the following activity as you proceed.

Demonstrating Products of Soft Coal. Set up the apparatus shown on text page 333. Supplement this activity with a supervised study and discussion of the booklet *Coal—Plant Life to Plastics.*

Preparing Exhibits on Petroleum. The American Petroleum Institute will send literature, filmstrips, and materials for class displays. Pupils can prepare supplementary charts to show methods of petroleum exploration. The Standard Oil Company of New Jersey or California will send exhibits and literature.

For the Bulletin Board. Post pictures of important mineral resources and collect data as to the amounts of oil, coal, and metal ores obtained during the past year. Include data from previous years.

For each resource mineral, post a list of derived products.

Films. Free filmstrips such as *Oil: From Earth to You* (accompanied by a teacher's guidebook) and *Petroleum in Today's Living* will help illustrate pupil reports and aid in discussion and review.

HELPING THE SLOW LEARNER

Ask the slow learner to list the parts of his bicycle which need lubrication and explain why they need it. What kinds of lubricants are used in an automobile? (Greases, oils.) List which parts of the automobile are greased and which parts are oiled.

Suggest that the slow learner rub two coins together and then place a drop of oil between them and repeat the procedure. What happens to metal parts which rub together without any lubricant between them?

He can collect samples of minerals, alloys, and derived products described in this chapter.

HELPING THE RAPID LEARNER

The science-prone student can investigate the phenomenon of the lowering of melting-point in the formation of solder and Wood's metal. Consult a college chemistry book.

Have him do library research into chemical engineering as a career. Many companies listed on text page 345, as well as U.S. government agencies, have pamphlets on vocational opportunities.

He may help you send for free films and filmstrips from companies listed in chapter 12 of *A Sourcebook for the Physical Sciences,* and then preview them in a free period to make notes for a report or class presentation.

SUMMARY AND USE OF TESTS

The importance of the earth's storehouse of materials can be shown by extending the learning situation to the home. Chemistry as a hobby will help bring to the student practical knowledge of many common chemical substances. A suggestion or assignment can help him realize the many possibilities for exploration of common chemical reactions in the home. Interest can be stimulated by such activities as testing for acids or bases with simple materials. A student need not have an extensive home laboratory to do the observations on text pages 346-49.

Harbrace Teaching Tests to accompany *You and Science* consist of two 112-page booklets of objective-type tests, Forms A and B. They contain four chapter tests and a unit test for this unit.

BIBLIOGRAPHY FOR STUDENTS

1. *Adventures Inside the Atom,* General Electric Corp. Free comic book which is helpful to the slow reader.
2. *The Atom in Our Hands,* Union Carbide and Carbon Corp. Booklet, free in quantity.
3. Bischof, G. P., *Atoms at Work,* Harcourt, Brace, 1951.
4. Brinckerhoff, R. B., and others, *The Physical World,* Harcourt, Brace, 1958.
5. *Coal—Plant Life to Plastics,* Bituminous Coal Inst., Washington, D.C. Free set of booklets.
6. Fermi, L., *Atoms for the World,* University of Chicago Press, 1957. The wife of the late nuclear scientist Enrico Fermi tells about his life.
7. Freeman, I. M., *All About the Atom,* Random, 1955.
8. Freeman, I. M., *Invitation to Experiment,* Dutton, 1940.
9. Haber, H., *Our Friend the Atom,* Simon and Schuster, 1957. Contains many diagrams in color by Walt Disney artists.
10. Hecht, S., *Explaining the Atom,* Viking, 1954.
11. Hyde, M. O., *Atoms Today and Tomorrow,* Whittlesey, 1955.
12. May, J., *There's Adventure in Chemistry,* Popular Mechanics, Chicago, 1957.
13. Pollack, P., *Your Career in Physics,* Dutton, 1955. Includes a section on opportunities in the field of atomic energy.
14. Schwartz, J., *It's Fun to Know Why: Experiments with Things Around Us,* Whittlesey, 1952.

BIBLIOGRAPHY FOR TEACHERS

1. Conant, J. B., and others, *Harvard Case Histories in Experimental Science,* Vol. 1, Harvard University Press, 1957.
2. Jaffe, B., *Chemistry Creates a New World,* Crowell, 1957.

3. Joseph, A., and others, *A Sourcebook for the Physical Sciences*, Harcourt, Brace, 1960.
4. Mann, M., *Peacetime Uses of Atomic Energy*, Crowell, 1957. Non-technical explanations.
5. Schenberg, S., and others, *Laboratory Experiments with Radioisotopes for High School Science Demonstrations*, AEC, 1953.
6. *Water*, 1955 Yearbook of Agriculture, U.S. Dept. of Agriculture, Washington, D.C.

CHEMISTRY AS A HOBBY (text pages 346-49)

Pupils able to observe and even perform classroom chemistry activities are often eager to try additional ones at school or at home. For example, a home assignment which calls for a series of observations of the reaction of red or blue litmus paper with various materials will afford a welcome change of pace. Stress that a home chemistry laboratory need not be an elaborate affair. Neither is it necessary for a pupil to buy an expensive "chemistry kit."

If a group of students exhibit great interest in learning more about chemical reactions, why not suggest some chemistry projects for the general science club? These students would appreciate the opportunity to visit the high school chemistry laboratory and meet with students on the laboratory squad. Arrange to have chemistry students from the high school speak and perform additional demonstrations before your general science class. Such visits often prove more inspirational than formal demonstrations by a teacher. If there is a chemical concern in your area, try to arrange for a visit to the plant. Your group of hobbyists may want to compile a list of chemicals of direct significance to their community.

Perhaps the school library will subscribe to the chemistry publications of Science Service. The books on text page 349 might be ordered for the library. Parents of chemistry-minded children will appreciate suggestions of books suitable for gifts.

The high school chemistry teacher may help you compile a list of cautions to be observed by the home experimenter. The danger of fire, exposure to caustic chemicals such as lye, and possible damage to clothing and home furnishings should constantly be kept in mind.

UNIT 6

Improving the World's Food Supply

GENERAL THEME: *Man is continually learning new facts about how to conserve and improve plants and animals, but he is still dependent on them.*

The student sees how green plants make food and what they need to make this food. He learns how science improves the growth of plants by giving them better food from better soils (text pages 350-82). Then he is given an understanding of how plants make new plants—through fertilization of flowers, from seeds, and by reproduction from one or two parent plants. Asexual and sexual reproduction, taught in this way, leads to an understanding of animal reproduction and breeding of animals on a farm (pages 385-403).

The pupil also sees what science is doing to increase the yield of plants and animals for his better living and to preserve his inheritance through conservation (pages 407-12). He sees the importance of keeping natural life in balance and yet protecting our food supplies from predators and parasitic organisms. Finally, the section on conservation shows the importance of protecting our fields and forests from fire, insects, and disease (pages 413-23). This is a good time for a field trip (to a pond or field); the pupil may bring back some common fishes or plants which he should be able to identify from a simple key of the plant or animal kingdom (pages 425-33).

The Unit Inventory. It is suggested that, before beginning study of this unit, the pupils be permitted to test themselves on how much they know about the world's food supply by answering the questions on text page 350. In this way you and they will be better able to plan the amount of time needed to develop each concept in the unit.

PLANNING AHEAD

So that you may plan ahead for a particular film, equipment needed for demonstration or experiment, or a special program, the following items are listed in the order mention is made of them in the unit. A more complete list of films, arranged by topics, appears on Manual page 202.

FILMS AND FILMSTRIPS

f = film   c = color   fs = filmstrip

Chapter 18

1. *The Atomic Greenhouse: Tagging the Atom* (f), AEC, 1954, free loan.
2. *Gift of Green* (f,c), N.Y. Sugar Research Foundation, 1946.
3. *Green Plants—Food Factories for the World* (fs,c), Harbrace, 1957.
4. *Leaves* (f), EBF, 1936.
5. *Photosynthesis* (f), UWF, 1950.

Chapter 19

1. *County Agricultural Agent* (f,c), Venard Organization, 1955, free loan.
2. *Food and Soil* (f), 1945; *Muddy Waters* (f), 1944; *Raindrops and Soil Erosion* (f,c), 1947, all on free loan, U.S. Soil Conservation Service.
3. Soil Conservation filmstrips, EBF (in black and white), 1950: *How Long Will It Last?; How Soil Is Formed; Plant Life and the Soil; Water and the Soil; Animal Life and the Soil; Minerals in the Soil; How Man Has Used the Soil;* and *How Man Conserves the Soil.*

Chapter 20

1. *Breeding Better Food Crops* (f,c), Natl. Garden Bureau, 1949.
2. *Development of the Frog* (f), Ohio State U., Photo Lab., 1951.
3. *Flowers at Work* (f), EBF, 1950.
4. *Improving Strains of Livestock* (f), EBF, rev. 1954.

Chapter 21

1. *The Battle of the Beetles* (f,c), U.S. Forest Service, 1952, free loan.
2. *Bounty of the Forest* (f,c), Western Pine Assoc., 1953.
3. *Life of the Honey Bee* (fs,c), Soc. for Visual Ed., 1951.
4. *Man's Problems* (f,c), EBF, 1957.
5. *Man Against Insects* (fs), Popular Science, 1951.

EQUIPMENT FOR DEMONSTRATION AND EXPERIMENT

Chapter 18

variegated ivy or coleus, silver-edged geranium, Lugol's (iodine) solution, 70% ethyl alcohol, pictures or specimens of green and albino corn, fresh-water snail, elodea, large test tubes, rubber stopper, paraffin, bromothymol blue (0.1%), microscope, various leaves, hand magnifiers, celery stalk, red ink, potassium permanganate, Petri dish, overhead projector, starch, goldbeater's membrane, cellophane, corn seed (normal and albino types), filter paper

Chapter 19

litmus paper, modeling clay, matchsticks, green cellulose sponge, seeds (radish, oat, mustard), sand, paper cups, empty eggshells, vermiculite, lime, vinegar

Chapter 20

jars, fruit fly cultures, gauze (cheesecloth), cellophane, yeast cake, microscope, seed catalogues, lima beans; fresh green peas (in pods), sweet pea flowers, hand magnifiers, geranium, ivy, coleus, privet stems, pictures of new varieties of plants and animals

Chapter 21

mealworms (Tenebrio), insect cocoons, chrysalids

FIELD TRIPS TO BE ARRANGED

Local plant nursery or garden supplies store. Agricultural experiment station (or research laboratory of university).

CHAPTER 18: FOOD FACTORIES OF THE WORLD
(text pages 352-70)

• CONCEPTS AND KEY ACTIVITIES

1. *Green plants can make food and oxygen with the aid of light and chlorophyll.*

2. *Materials for food-making come from water, soil, and air.*

One way to start is to test a green-and-white (variegated) ivy leaf, or a silver-edged geranium leaf, for starch. Elicit reasons why the white portion does not contain starch. You may then have pupils design experiments to show the importance of light, carbon dioxide, and chlorophyll for starch-making in a green plant. (During photosynthesis most plants store glucose in the form of starch.)

It may be more feasible to develop the idea of food-making in plants by showing photographs of albino corn seedlings. Have pupils account for the fact that the young albino plants die in a short time. (After the food stored in the corn grain has been depleted, the plant dies because chlorophyll needed for food-making is lacking.)

Another approach to the concept is to seal a small snail and a sprig of a water plant such as elodea *(Anacharis)* in a glass test tube, closing it with a rubber stopper and a paraffin seal (or adhesive tape). Student questions can then be discussed. (Will the snail die? Where will it get food?). Careful questioning will lead the class toward the idea that green plants make food.

Still another approach is to use the bromothymol blue experiment on text pages 354-55. Use 0.1% solution of bromothymol blue. The aquarium water should be that in which the water plants for the experiment have been growing. Ask the class to explain the results. Elicit the need for controls in each part of the experiment. There are many additional suggestions in *A Sourcebook for the Biological Sciences*.

PLANT CHARTS

At page 400, there are four full-color pages showing the structure of the corn plant. From time to time as your students work through activities, use the text and illustrations at these pages to clarify and extend the concepts of plant structure.

For the Bulletin Board. Pupils can collect pictures of foods that contain starch. Then they can collect samples and test each one with iodine solution (Lugol's solution). The test data can be included under each picture. Pictures of food plants can also be posted; use colored string radiating out to pictures of various food products derived from a specific plant.

Demonstrating Leaf Structure. If a microscope is available, have pupils peel strips of leaf surface (epidermal) tissue from such plants as fern, *Tradescantia*, or succulents like *Peperomia*. To peel off the tissue have them use forceps or tweezers or make a short zig-zag tear and gently pull the leaf blade away from the torn area. The translucent edge will show many air pores or stomates, especially if the lower epidermis is used. Do all leaves have air pores on the lower surface only? Ask pupils to devise a procedure to answer this question. Some plants have air pores on both surfaces; the water lily leaf has stomates on its upper epidermis only. Ask pupils to explain why stomates on the water lily's lower leaf surface would be ineffective. (The lower epidermal area is submerged.)

Films and Filmstrips. The Harbrace filmstrip *Green Plants—Food Factories for the World* may be used for review, or frames 1-10 can introduce the concept with such questions as: What would happen if all green plants disappeared?

A color film, *Gift of Green*, has animated sequences and time-lapse photography. It makes a good summary lesson. *Leaves* and *Photosynthesis* are two films which may be used in connection with class discussion. A free film, *The Atomic Greenhouse: Tagging the Atom*, may be borrowed from the U.S. Atomic Energy Commission field offices.

Field Trip. If there is a plant nursery (or garden supply store)

near you, arrange for the class or a committee to visit and make observations. Why do people buy commercial and organic fertilizers (such as steer manure)? Jot down the minerals and their percentages as indicated on the containers of commercial fertilizer. Look up some of the specific effects of nitrogen, phosphorus, and potassium on plant activity. (This library project can be supplemented by experiments to show the effects on a green plant of a deficiency of a given mineral.)

Following the Progress and Results of a Pupil Project. A committee interested in using hydroponics to test effects of minerals on plant growth can refer to the free leaflet *Hydroponics: Growing Plants in Nutrient Solutions Without Soil*. Suggest that pupils devise additional experiments to test for symptoms of mineral deficiency and make regular reports to the class. *Soilless Growth of Plants* and *Soilless Culture Simplified* will be helpful.

Demonstrating Root Hairs. An interesting home or classroom assignment is to allow pupils to grow and observe radish seedlings. Suggest they bring plastic containers (flat ones are excellent) and line them with moistened dark blotting paper. A hand magnifier can be used to examine root hairs through the side of the container. What happens when the root hairs are allowed to dry for a very short time? Develop a discussion on increased absorption surface. How might you trace the path of water through a plant? (Place a celery leaf stalk in red ink.)

Demonstrating Diffusion of Minerals. Drop a crystal of potassium permanganate into water in a shallow dish (or use a Petri dish and project the diffusing substance with the overhead projector). Ask pupils how diffusion through the water may be speeded up (stir or warm the liquid).

Ask how water and minerals enter a plant. To show diffusion through the root hair membrane, pour 1% starch paste into a test tube and cover the mouth of the tube with a wet goldbeater's membrane or with moistened cellophane held in place with a rubber band. Insert this "root hair" test tube into a beaker of dilute Lugol's (aqueous iodine) solution. Have pupils interpret their observation that the starch inside the tube turns blue. Elicit a comparison of diffusion of iodine molecules into the test tube with diffusion of water and minerals into root hairs.

HELPING THE SLOW LEARNER

Have the slow learner plant and care for normal and albino (colorless) corn seedlings.* Use the exhibit to introduce the concept of photosynthesis. When the seedlings are 4" to 6" tall, suggest that the student preserve his specimens by drying them

*Obtain seed from the Brooklyn Botanic Garden, Brooklyn 25, N. Y.

between the pages of an old telephone book. Then glue the dried specimens to heavy paper and display, with captions, on the bulletin board. Pupils might devise titles such as "Why did this (albino) plant die?" The slow reader will find *The First Book of Plants* easy to read and well illustrated.

HELPING THE RAPID LEARNER

The strongly science-prone student may wish to probe deeper into basic ideas of photosynthesis by reading important articles by E. I. Rabinowitch in the August 1948, March 1949, and November 1953, issues of *Scientific American*. A companion reading research project (for the teacher) is the section of "Science Reading and Understanding," which discusses how to teach by the use of a current scientific article. Rabinowitch's August 1948 article on "photosynthesis" is used as the illustration. This may enable you to check the reading comprehension of your very bright youngster. There are objective-type questions which you can give to see whether the pupil can recognize and state problems; evaluate and apply information; and recognize, state, and test hypotheses and conclusions.

The science-prone child may want to construct a microaquarium, using a large soft-glass test tube (see pages 86-87 of *A Sourcebook for the Biological Sciences*). Analysis of chlorophyll by means of paper chromatography may interest him to read in depth. Place a strip of filter paper into a fresh alcoholic extract of chlorophyll. Chlorophyll A and B and xanthophyll spread through the filter paper by capillarity at different velocities. The dried paper will show a different level for each substance.

If he has access to a microscope, the bright pupil may devise a procedure to determine distribution and number of stomates in the upper and lower epidermis of plants of different species; also, of plants from different environments. A rough estimate can be made by counting the stomates under the 16-mm. objective lens. This field is approximately one square millimeter. Make sample counts in different regions of the leaf and secure an average figure for one square millimeter.

Have the bright pupil write to the AEC (with your written endorsement on school stationery) for free materials describing the use of tracer elements in plants. Also, ask for the free reprint of the "photosynthesis" article (August 1948) from the *Scientific American* as well as the booklet *Some Applications of Atomic Energy in Plant Science*.

CHAPTER 19: BETTER FOOD FROM BETTER SOIL
(text pages 371-84)

• CONCEPTS AND KEY ACTIVITIES

1. *By protecting and improving the quality of the soil, we can grow better plants and animals.*

Have pupils bring in soil samples from different places (school garden, home garden, vacant lot, flower pots, etc.). Organize into groups and use magnifiers to examine soil for living organisms and soil texture and other physical properties. Ask the class how they would determine the acidity or alkalinity of soil (litmus paper). Or show pictures of agricultural experiments with one plot of ground filled with vigorous plants, the other, with stunted plants. What do you think happened here? From this, go on to the concept by eliciting how man can improve the quality of soil.

Field Trip. If your school is in or near a rural area, a visit to the local agricultural agent may reveal to the pupils how new methods of soil improvement are applied in their community. A free film, *County Agricultural Agent*, may take the place of a visit for those schools which are unable to take this field trip.

Demonstrating Types of Soil. Pupils may set up apparatus similar to that in Figs. 192 and 193, on text pages 372-73. Discuss the importance of soil drainage.

Arranging for Pupil Projects. If your school has limited yard or garden facilities (such as in a large city), students can construct earth-filled boxes, planting grass in one and leaving bare soil in the other. Tilt the boxes and direct a gentle spray of water from a watering can equally over both. Collect run-off samples, measure the amount, and note the sediment in each.

Library reports can be assigned on such topics as causes of soil destruction (by floods, overgrazing, overplanting, etc.), and addition of radioactive isotopes to fertilizers as tracers to learn amounts and kinds of minerals different crop plants take from the soil. (The AEC will send free illustrated literature.)

For the Bulletin Board. Pupils may bring in photographs which they have taken of soil erosion-control projects. Or news reports on floods can be posted. A committee may undertake an investigation to find out whether a forest fire, a lumbering operation or other land change had taken place in the region, thus contributing to the rise of flood waters.

Supplementary Reading. *The Web of Life* (Signet Key paperbacked edition, 35¢) is an excellent source of information on soil

problems. It may be obtained from the publisher at a discount for quantity purchases.

Soil (the 1957 Yearbook of Agriculture) and *Land* (the 1958 Yearbook of Agriculture) may be obtained free from your U.S. senator or congressman. The eight pages of photographs following page 336 in *Soil* show principles of good and poor soil practices. You may find these pictures not only of interest to slow readers but also a good basis for discussion.

You may wish to build up your teaching file with free publications of the U.S. Soil Conservation Service, Washington, D.C. For instance, the *Outline for Teaching Conservation in the High School* has many good ideas.

Suggestions for a Group Project. A model diorama of scenes which shows how the soil is used wisely can be made with modeling clay, matchsticks, bits of green cellulose sponge (or reindeer moss), etc. Pupils can gather information from such sources as encyclopedias, government publications, and textbooks on conservation. Suggest that each pupil in the project write a full description of the scenes portrayed in the diorama.

Films and Filmstrips. You may have a choice of several free loan films if you order them early in the term. *Soil Erosion* shows the causes of land destruction, and describes soil conservation measures. The films *Food and Soil, Muddy Waters,* and *Raindrops and Soil Erosion* are all available on free loan from the Soil Conservation Service.

An excellent filmstrip series on soil conservation (see the titles of the eight filmstrips on Manual page 134) can be used for review, in student project reports, and for discussion.

HELPING THE SLOW LEARNER

The science-shy child will enjoy working on simple soil study projects. Furthermore, his ability to show these activities and therefore make contributions will give him a feeling of satisfaction. He can attain further status by studies of soil suggested on text pages 372 and 374. He can demonstrate the binding force on soils of the roots of different plants. Germinate radish, oat, and mustard seed in paper cups filled with moistened sand or top soil (soaking the seeds first will speed their germination). Let the seedlings grow for two weeks but water them sparingly. Root systems will be more extensive when the plants have not been heavily watered. Tug on the shoots and see the effect on the soil held by the roots. Compare root distribution of different types of seedlings. For smaller seedlings substitute empty eggshells cut crosswise and filled with vermiculite or other light absorbent mineral compound.

The slow learner can test the acidity of different soils. Acid turns blue litmus red; alkaline turns red litmus blue. Collect soil samples from different levels at a given spot; a post hole digger is a handy tool. In addition, samples of soil from different places, such as a beach, a swamp, woods, burned-over land, a garden, etc., can be collected. Place mostened strips of both red and blue litmus paper in separate glass dishes or on glass slides. Then put ½ teaspoon or less of a soil sample on each strip. It may be necessary to add several drops of water to drier soils. Then turn the glass dish or slide over and examine the color of the litmus paper. The teacher can prepare alkaline soil by adding a bit of lime to a soil sample; acid soil by adding a small amount of vinegar. Ask the pupil how acid soil can be made less acid.

The slow learner may be interested in performing the activity with acid and neutral soils mentioned on text pages 383-84.

HELPING THE RAPID LEARNER

Reading in depth for the science-prone pupil can include such sources as *Land*, the 1958 Yearbook of Agriculture. Pages 392-401 describe "The Care and Use of National Forests"; "Urban Expansion—Will It Ever Stop?" (pages 503-22) is a thought-provoking article on wise use of *city* land.

Have the bright student consult the *Readers' Guide to Periodical Literature* for articles on the use of tagged atoms as tracers in soil studies. Write to the AEC for literature on this topic.

If it is feasible, have him plan and make a survey of soil conservation practices (or the misuse of land) in his area. A pupil committee can tabulate data for discussion.

CHAPTER 20: PRODUCTION THROUGH REPRODUCTION (text pages 385-406)

• CONCEPTS AND KEY ACTIVITIES

1. *Some living things produce young asexually (one parent), others sexually (two parents).*

2. *Flowering plants and most animals reproduce by the process of fertilization of an egg by a sperm.*

One way to start is to duplicate Redi's experiment with flies as a pupil project. Or you may wish to set this project up as an outcome of a discussion lesson on the origin of living things from

other living things. The procedure is to place equal amounts of raw meat into three jars. Leave one jar open, cover the second jar with gauze, and the third with a sheet of cellophane. If weather permits, set them outside the classroom window. Pupil observers can record the number of flies in proximity to each jar (take observations at half-hour intervals). Elicit suggestions as to why Redi's experiment was significant in his day. Why do we use three jars? Develop the idea of controls and the concept of reproduction among living things. Try fruit flies *(Drosophila)* if you wish to perform the experiment indoors. Fruit fly cultures may be purchased from biological supply companies listed on Manual page 225. (If you plan to have brighter pupils do some simple heredity studies, contact the genetics laboratory of an institution such as the California Institute of Technology. They are most cooperative and will mail you a vial of *Drosophila*, if you mention the reason for your request.) Or refer to *A Sourcebook for the Biological Sciences*, p. 196.

Or you may have pupils bring in samples of pond water (or even stagnant water) and examine protozoa under low power. Start a discussion of the means of reproduction in these organisms. This may be a good time to refer to the photomicrographs and drawings on text page 386. Also refer from time to time to the Plant Charts in full-color (at page 400) to review or reinforce concepts.

Demonstrating Asexual Reproduction in Yeast. Add a piece of fresh yeast cake to dilute molasses and have pupils examine under high power (cut down the light to avoid poor contrast resulting from glare). Have pupils count the budding cells in one field of the microscope. Have them record their observations and the type of reproduction on a large chart. Lead into other methods of asexual reproduction.

Demonstrating Forms of Asexual Reproduction. Organize the class into small committees and suggest each group grow plants such as carrot, onion, sweet potato, beet, white potato, etc., and record the results observed when these plants are submerged partially in jars of water. Caution them to change the water *daily*. (If molds or decay bacteria appear, their appearance might provide opportunity for further research: How did the bacteria or mold plant increase in amount?)

The committee work can be set up around the classroom, or be extended as a home assignment.

For the Bulletin Board. Seed catalogues will describe different varieties of roses, with accompanying illustrations. Place questions under the pictures: "How were these new varieties obtained?" Also, "How can the plant breeder make certain he can obtain many rose plants all of the same appearance?" You may then lead into a discussion of cuttings and grafting.

Demonstrating Origin of Seeds. Pupils may examine lima bean seeds soaked according to the directions on text page 390. If you can obtain fresh green peas (in pods), allow pupils, working in pairs, to examine and make drawings of the relation of the pea to the pod wall and the appearance of the embryo plant surrounded by the fleshy seed leaves. Ask for suggestions on the origin of the embryo. If there are no helpful comments, allow for further research. Distribute sweet pea flowers (ask pupils to bring some from their gardens, or a florist may give you frayed sweet pea flowers at no charge). Make a longitudinal slice through the base of the pistil (the ovary) after the pupils have noted the close resemblance between the ovary wall and the wall of the pea pod. Examine the ovules within the ovary, using hand magnifiers, and elicit the statement that the seeds started to develop at the site of the ovules. Refer to charts or models of flowers (also Fig. 206, page 392) and then discuss pollination and fertilization.

Demonstrating Pollen and Pollen Tube Growth. A committee can make separate slides of pollen from different flowers and note the size and shape of each type of pollen. To show germinating pollen grains brush some ripe anthers (top of the stamens) against the sticky stigma (top of the pistil). Then crush the stigma in water, place on a slide, add one or two bristles, and a cover slip. The bristles prevent the cover slip from crushing the growing pollen tubes. The pollen tubes of most plants will grow in a 10% cane sugar solution.

Demonstrating Developing Tadpoles. Pupils may bring in fertilized frog or toad eggs. Place small quantities in finger bowls or jars. Add aquarium plants and aquarium water. As the hatched tadpoles get larger, add a bit of boiled egg yolk. Be sure to remove excess food and change the water soon after feeding to avoid fouling. Pupils can make drawings and keep records of the stages of development. At intervals of several days, drop a tadpole into a vial of 70% alcohol to preserve it and note the date. Mount the vials in sequence on a large piece of cardboard. Refer also to the Frog Charts at page 432.

Films. Pupils can examine and discuss pages 394-96, which show stages in frog development, as well as the Frog Charts in full color at page 432. Then show *Development of the Frog*, stopping the film at times to ask review questions and to pose questions to be answered after the film has been shown.

Flowers at Work shows floral parts as well as descriptions of pollination and fertilization.

Other Activities on the Frog. The full-color frog charts between pages 432 and 433 are followed by a page of activities which you may decide to initiate with interested pupils or a committee at this time.

HELPING THE SLOW LEARNER

Have the slow learner make cuttings of stems such as geranium, ivy, coleus, privet, etc. With a sharp knife, cut squarely below a node and remove most of the leaves to decrease water loss. Grow in coarse, damp sand, or in water that is changed daily. He can set them up as a display together with explanatory captions.

3. *Plant and animal breeders make use of principles of reproduction and inheritance.*

If you have a pupil who raises and breeds tropical fishes, ask him to talk on his hobby, illustrating it with specimens. Encourage the class to ask questions about desirable traits in the variety being bred. What success has he attained? Does he have any hybrids? Then go into methods a breeder uses.

Or show various examples (pictures or photographs) of plant and animal breeding. Ask pupils to bring in examples of fruits and vegetables unavailable forty or fifty years ago. Illustrated seed catalogues are a good source of pictures of new varieties of apples, oranges, pink grapefruit, beardless wheat, ears of hybrid corn, new flowers, etc., which can be added to the bulletin board.

Readings. A committee can help assemble research materials such as the 1936 and 1937 Yearbooks of Agriculture, which describe improvements in plants and animals through breeding. Also, the Yearbook for 1943-47, *Science in Farming*, has chapters giving case histories of new types of plants and animals. Also, see the references on text page 406.

Demonstrating the Effect of Environment on Inheritance. Refer to the albino corn experiments on Manual page 135. Review the importance of chlorophyll and elicit the idea that plants inherit ability to produce chlorophyll. Ask pupils to suggest how they may demonstrate that plants need the right surroundings (light) in order to develop chlorophyll. Plant a batch of soaked seeds in the dark. As soon as the seeds begin to germinate, remove half of them to a lighted room. Note that the seedlings in the dark fail to show green pigment. Bring out that the best traits develop to their fullest in the best environment.

Or you may have pupils take cuttings of the same length from a single coleus plant and place some in deep shade, others in moderate light, and still others in bright light. Note the differences in color development.

Field Trip. A visit to a farm, an agricultural experiment station, or a college genetics laboratory may be a valuable experience especially for the science-prone pupil. It might result in obtaining several animals (or plants) for project work.

Films. *Improving Strains of Livestock* and *Breeding Better Food Crops* (free loan) can be used to summarize the concept.

HELPING THE SLOW LEARNER

Ask whether any of these pupils raise pigeons or other animals. Have them bring some of the birds to class and explain how they go about breeding them. Or they may cross hooded black rats with albino ones to see which trait will appear in the next generation.

The heredity diagrams on text pages 399-401 will have to be explained carefully with the aid of colored chalk and modeling clay used to simulate genes.

HELPING THE RAPID LEARNER

Encourage the rapid learner to read some chapters (most of them very short) in *The New You and Heredity*. This excellent book contains information on inheritance of human eye color, hair color, and musical genius.

If you demonstrate growing pollen grains, suggest that the rapid learner do original research to determine the best percentage of cane sugar medium for the pollen of a given flower. Have him outline his procedures in advance.

Additional extended work will involve him in studying the effect of plant growth substances (such as auxins) on root development on stem cuttings. Beta-indolebutyric acid and alpha-naphthaleneacetic acid are effective. The plant nurseryman sells such commercial preparations as Auxilin, Hormodin, Rootgro, and Rootone. The bright pupil can devise a series of experiments to show the effects of the same hormone on twigs of different ages, different species, etc. Have him dip the cut ends of the stems in water and then into the powder and remove the excess by shaking. Plant the cuttings in wet sand; make certain there are adequate controls.

CHAPTER 21: WISE USE OF OUR INHERITANCE
(text pages 407-24)

• CONCEPTS AND KEY ACTIVITIES

1. *Our inheritance may be preserved longer by good conservation practices.*

2. *It is important to keep a natural balance among living things and protect our food materials from disease and insects.*

One way to start is to have pupils list what they consider important natural resources. Which ones are being used wisely? Are there any that are being depleted rapidly? From this point, go on to possible ways man can employ sound conservation practices.

Cite examples to show the balance of nature has been upset by man or by other living things or by physical factors. Ask pupils to account for the increase in field mice after chicken hawks had been killed off in some communities. Is there any danger in overprotecting deer in some regions? How can disease, flood, forest fire, or drought upset the balance?

A Library Lesson. Arrange with the school librarian for a collection of such references as the 1952 Yearbook of Agriculture (*Insects*), the 1949 Yearbook of Agriculture *(Trees)*, a class set of the 35¢ paperback *The Web of Life* (New American Library), *Guarding Our Wildlife Resources*, a pamphlet by Rachel Carson for the Fish and Wildlife Service, and many other government and private publications.

Inasmuch as the concept of conservation is an immense one, the class, under its chairman, can divide itself into groups to study various aspects. Group research subtopics can center around the food chain and the balance of nature (including examples of upsets), adaptations which enable some plants and animals to get along very well, insect life cycles, insecticides, fungicides, protection of our forests, etc.

If this is the first visit to the library, a demonstration of the cataloguing and storing devices and how to use them can be given. The class can commence work right after the demonstration, and each pupil completes his assignment after class. Students then report the next day on what they have learned.

Demonstrating Insect Life Cycles. Pupils may bring in examples of materials damaged by insects. Develop the idea that knowledge of different phases of an insect's life cycle helps man determine which phase is most vulnerable to control, which causes the most damage, etc.

Pupils can bring in larval stages of different insects with the food plant on which they were found. Continue observations in the classroom and note any changes. A handy reference is *Insects*, the 1952 Yearbook of Agriculture. It contains seventy-two pages of colored plates and descriptive captions (following the index). Simon and Schuster's Golden Nature Guide *Insects* is excellent, especially for the slow reader.

The larval stage of the meal-worm beetle *Tenebrio* can be purchased in some pet stores in larger towns and cities where the insect is sold as food for turtles and chameleons. Distribute young larval forms in small containers filled partially with corn meal. Compare the main culture with the diagrams of beetle developmental stages shown on text page 417. Which stage does the most

damage? Send for the free Turtox leaflet *Insect Metamorphosis*, which describes how to maintain living material in the laboratory and thus demonstrate different types of insect life cycles.

A Committee Trip. Arrange a visit to a garden supply store at a time when the store is not very busy. Pupils can note the type of insecticides and fungicides sold. Note the methods of application by examining the directions on the containers. What garden pests other than insects and fungi exist? (Moles, gophers, rabbits, mice, etc.) Summarize the results of the visit on a chart for display.

For the Bulletin Board. Under the main heading "How man has upset the balance of nature?" have pupil groups collect photographs, pictures, and clippings for these subheadings:

1. Introducing new organisms into an area.
2. Forest fires due to carelessness.
3. Excessive lumbering.
4. Overgrazing of land by cattle and sheep.
5. Overcultivation of land.
6. Pollution of air, soil, and water.
7. Paying bounties for destruction of certain animals.
8. Breeding new animals and plants.

Film. A free U.S. Forest Service film, *The Battle of the Beetles*, describes an important aspect of forest control.

HELPING THE SLOW LEARNER

Determine the interests or hobbies your slow pupils may have. If some have gone camping, allow them to present a short talk on the care of a camp area, including fire safety. Perhaps the school grounds contain a garden or farm area. Students who are shy in formal class work may suddenly perk up with a garden project or when encouraged to work up a demonstration area illustrating good soil practices, such as terracing, contour plowing, etc.

With colored modeling clay, bits of green cellulose or rubber sponge, etc., he can make a simple diorama which shows a scene before and after a forest fire.

Have the slow learner collect cocoons or chrysalis cases and try to hatch out the adult insect. Collect praying mantis egg cases if they are available. Feed the young forms small insects such as fruit flies. Compare with the grasshopper diagrams on text page 416.

3. *The protection of our fields and forests depends on knowledge and co-operation between people.*

A pupil may present a library research report, assigned in advance, on disastrous forest fires in our recent history. Chapter

12 of *The Web of Life* contains three short but exciting pages of the destruction caused by Engelmann's spruce beetle (text page 422) in the White River National Forest, in Colorado. This story can be read by the class (or described by a pupil). How have the beetles contributed to the forest fire danger? (Dead wood soon becomes tinder dry.)

Films and Filmstrips. *Life of the Honey Bee* is a filmstrip which shows the characteristics, habits, and adaptations of this beneficial insect. *Man Against Insects* depicts the life cycles and structures of insects, and discusses which insects affect man.

Methods of logging and uses of wood may be seen in the *Bounty of the Forest* (free loan). *Man's Problems* includes scenes of dam construction, control of rivers, and sources of fresh water supply.

HELPING THE SLOW LEARNER

A poor reader may be encouraged to borrow from the school library (or the children's branch of the public library) such books as *Lookout for the Forest* by Glenn Blough or *The First Book of Conservation*, which has a simple study of the need for conservation of animal and plant life.

Have the slow learner collect specimens of plants and small animals such as insects and bring them to class. He may construct a chart using pressed tree leaves and give a short statement on their uses by man.

HELPING THE RAPID LEARNER

The rapid learner may, over a period of time, study a community of living things (a biome) in such areas as a swamp, pond, meadow, his backyard, or a remote part of a city park. Let him make records of the kinds of organisms and the physical features of the area. Are there any enemies which hold the existing organisms in check? He can use his camera or draw diagrams of some of the living things noted. Refer to text page 428 for references.

If there is a conservation agency in your region, suggest that the pupil interview an official and report his findings.

SUMMARY AND USE OF TESTS

Pupils should realize that the problem of improving the world's food supply depends not only on new forms of plants and animals, but on the wise and proper use of existing resources, including man himself.

An appreciation of living things can often be attained by developing hobbies such as bird study, butterfly collections, and collecting and observing water specimens. A hobby of this sort may even draw the family closer together while they try to learn more about the new "finds."

Harbrace Teaching Tests to accompany *You and Science* consist of two 112-page booklets of objective-type tests, Forms A and B. They contain four chapter tests and a unit test on this unit.

BIBLIOGRAPHY FOR STUDENTS

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2. Carson, R., *Guarding Our Wildlife Resources*, Fish and Wildlife Service, pamphlet, 1948.
3. Dickinson, A., *The First Book of Plants*, Watts, 1953.
4. Ellis, C., and M. W. Swaney, *Soilless Growth of Plants*, Reinhold, 1947.
5. *Insect Metamorphosis* and *Hydroponics: Growing Plants in Nutrient Solutions Without Soil*, Turtox Service Leaflets, free from the General Biological Supply House, 8200 S. Hoyne Ave., Chicago 20, Ill.
6. Laurie, A., *Soilless Culture Simplified*, McGraw, 1940.
7. Scheinfeld, A., *The New You and Heredity*, Lippincott, 1951.
8. Smith, F. C., *The First Book of Conservation*, Watts, 1954.
9. *Soil*, 1957 Yearbook of Agriculture; *Land*, 1958 Yearbook of Agriculture. Excellent references, free from your congressman.
10. Storer, J. H., *The Web of Life*, New American Library (35¢), 1956. Excellent supplement.
11. Zim, H. S., and C. Cottam, *Insects*, Simon and Schuster, 1951. Helpful to the slow student.

BIBLIOGRAPHY FOR TEACHERS

1. Dressel, P. L., and L. B. Mayhew, *Science Reasoning and Understanding*, W. C. Brown, 1954.
2. Morholt, E., P. F. Brandwein, and A. Joseph, *A Sourcebook for the Biological Sciences*, Harcourt, Brace, 1958.
3. *Outline for Teaching Conservation in the High School*, U.S. Department of Agriculture, Soil Conservation Service, free.
4. *Plant and Animal Breeding*, U.S. Department of Agriculture Yearbook for 1936 and 1937; *Science in Farming*, for 1943-47; *Insects* (excellent color drawings), for 1952; *Trees*, for 1949.
5. Rabinowitch, E. I., "Photosynthesis" articles in the August, 1948, and November, 1953, issues of *Scientific American*.
6. *Some Applications of Atomic Energy in Plant Science*, U.S. Atomic Energy Commission, free.

LIVING THINGS AS A HOBBY (text pages 425-33)

Observing, collecting, and classifying living things are popular with many children. If you are in an urban area, a field trip to a nearby park will result in a pleasant interlude from the formal classroom. A permit to collect is required in some parks. Ask pupils to note where they find various animals such as millipedes, sowbugs, beetles, caterpillars, ants, spiders, and frogs. Back at school suggest that committees further classify the living things with reference to such books as those listed on page 428. You will discover that some pupils will go back to the park on their own. Of course, students living in suburban and rural areas come into more contact with plants and animals. Nevertheless, they often need guidance in classifying and studying these organisms.

Committees can continue observations of living things in the classroom. Turtles, ants, crickets, crayfish, and toads can be kept in appropriate containers and cared for by students who are familiar with and can devise means to simulate their habitats. A free set of Turtox leaflets on the care and feeding of laboratory animals, among other subjects, may be obtained by writing on school stationery to the General Biological Supply House, Chicago, Illinois. (For the address, see Manual page 225.) Some pupils may begin to investigate the ecological relationship of the forms cited above, as well as the economic significance of the pests and beneficial organisms.

White and hooded rats, guinea pigs, and hamsters may be kept in cages constructed by shop students. It is important that responsibility for the care and feeding of the animals be shared by committee members.

FROG CHARTS

Some students may be interested in learning a few elementary principles of dissection. A frog offers opportunity for extended study and is not too difficult for able students to work on. Suggestions for beginning are given on text page 433. Reference to the frog charts in full color, which are found on the preceding pages, will prove helpful.

Plants may be propagated by cuttings; water plants and some small aquatic animals can be kept together in the same aquarium tank. Breeding and diet experiments with rats and hamsters can be one of the outcomes.

Some of your more interested students can supervise and care for a living materials center to supply other science classes or

schools within the district. *Drosophila* or fruit flies, mealworm beetles, plant cuttings, protozoa, and hamsters, for example, are much in demand.

The hobbyist in living things may become interested in birds (recommend he communicate with the Junior Audubon Society). A bird walk early in the morning with an interested group is a pleasurable experience. Cornell University records of bird songs might be played before the walk. In addition, discuss the feeding and nesting habits and show pictures of the most common birds in the vicinity. On a chart place the names or pictures of local and migratory birds. Opposite each, students can write notes they have taken in the field.

A project for a group of nature hobbyists is the laying out of a nature trail—either on the school grounds or in the local park, if permission can be obtained. Boys in the woodworking class can make signs which members can set up along the trail with the names of the trees lettered on them in paint. Attach the signs by means of plastic-covered wires around the trunk.

Chapter 14 of *A Sourcebook for the Biological Sciences* includes many valuable suggestions for projects for the high-ability pupil.

UNIT 7 Doing the World's Work

GENERAL THEME: Man's physical strength is limited; he makes use of machines for doing work.

In this unit, the pupil sees how science, by developing machines, has shortened distances on land, sea, and in the air, thus enriching man's way of living. The student investigates what energy is and how we control and change its form. He studies how work is measured and how we make use of simple machines, such as the lever. The idea of mechanical advantage and the method of calculating the efficiency of a machine is shown (text pages 436-53).

How man utilizes the energy from fuels is studied next. He sees that fuels don't always burn completely, and he goes on to understand how steam, gasoline, Diesel engines, and turbines do work by burning fuels to obtain energy (pages 454-74).

Inasmuch as electricity is used for lighting and heating and by most machines in the home, the pupil analyzes electricity in its static and current phases (pages 475-82). He sees the close connection between magnetism and electricity and how discovery of this connection by scientists led to the invention of machines such as generators that make electricity (pages 482-90). He begins to understand how electricity travels from the generating station to his home and how it is used in lighting, heating, and running electric motors (pages 490-99).

We depend on machines for fast and safe transportation on land, sea, and in the air. The student recognizes how important automobiles and trains are. Since he may drive an automobile some day, he sees how one operates and what rules for safety he should follow (pages 502-06). He learns why steel ships float and can carry huge cargoes and how submarines can travel below the surface of the sea. He becomes familiar with the simple parts of an airplane, how it flies, and how jet engines work (pages 508-23). At this point, it is a good idea to suggest building model airplanes to extend personal interests in air travel further (pages 527-31).

The Unit Inventory. Before beginning this unit, it is suggested that the pupils test themselves on how much they know about doing the world's work by answering the questions on text page 434. In this way you and they will be better able to plan the amount of time you need to spend on certain topics and specific activities to develop fully the concepts of the unit.

PLANNING AHEAD

So that you may plan ahead for a particular film, equipment for this unit or a special program, the following items are listed in the order they are mentioned. A more complete list of films, arranged by topics, appears on Manual page 202.

FILMS AND FILMSTRIPS

f = film c = color fs = filmstrip

Chapter 22

1. *Energy from the Sun* (f), EBF, 1955.
2. *Machines Do Work* (f), YAF, 1949.
3. *The Nature of Energy* (f,c), Coronet, 1949.
4. *Simple Machines* (f and fs), EBF, 1942.

Chapter 23

1. *The ABC of Internal Combustion* (f,c), General Motors, 1948, free loan.
2. *The Diesel Story* (f), Shell, 1952, free loan.
3. *Energy Unlimited* (fs,c), Harbrace, 1957.
4. *Fuels and Heat* (f and fs), EBF, 1938.

Chapter 24

1. *Basic Electricity* (f), Dept. of the Air Force, 1948, free loan.
2. *Electrostatics* (f), EBF, 1950.
3. *Elementary Electricity: Amperes, Volts, Ohms* (f), U.S. Civil Aeronautics Administration, free loan.
4. *Elementary Electricity: Current and E.M.F.* (f), U.S. Civil Aeronautics Administration, free loan.
5. *Energy Unlimited* (fs,c), Harbrace, 1957.
6. *Introduction to Electricity* (f,c), Coronet, 1948.
7. *Making Electricity* (f), EBF, 1949.
8. *Principles of Electricity* (f,c), General Electric, 1945, free loan.
9. *Story of the Storage Battery* (f), U.S. Bureau of Mines, 1947, free loan.

Chapter 25

1. *The A.B.C. of the Automobile Engine* (f,c), General Motors, 1949, free loan.
2. *Automatic Transmissions* (f), Ford, 1956, free.
3. *How the Airplane Flies* (f), Shell, free loan.
4. *Jet Power* (f), General Electric, 1954, free loan.
5. *Jet Propulsion* (f), General Electric, 1952, free loan. Also EBF, 1952.

EQUIPMENT FOR DEMONSTRATION AND EXPERIMENT

Chapter 22

alcohol lamp, gas burner, induction coil, lamp, electric motor, wood chips, wristwatch with radium dial, Pyrex test tubes, hand magneto, friction lighter, iron nail, glucose, Benedict's solution, table salt (sodium chloride), silver nitrate, fixed and movable pulleys, yardstick, spring balance

Chapter 23

glass chimney, candle, Bunsen burner, plain paper cups, tongs, white plate, soft glass tubing, toy steam engine, working model of steam engine, test tube, cork, one-gallon can, cylindrical tin can, tin snips, hot plate

Chapter 24

screw-top glass jar, one-hole rubber stopper, nail, aluminum foil, 1.5-volt dry cells, tumbler, vinegar, discarded storage battery, 6 small balloons, 15 bar magnets, magnetic toys, steel darning needles, bell wire, knife switches or push-button switches, paper clips, galvanometer, compass, cutaway electric meter (from electric company), 5 flashlight bulbs and sockets, blueprint paper, lead strips, dilute sulfuric acid, 3% hydrogen peroxide, powdered iron filings, electric bell

Chapter 25

bicycle, picture of different ships, aluminum foil, nail, one-pint plastic container, 18" rubber tubing, spring balance, beaker, plastic tubing, red ink, rubber sheeting, aquarium tank, pictures of airplanes, rubber balloon, glue, toy car or airplane, coffee can, string, basin, Ping-pong balls, string, Scotch tape, paper or plastic straw

FIELD TRIPS TO BE ARRANGED

Visits in school vicinity (to observe simple machines), to a local automobile repair shop, to an airfield, to an electric power station

CHAPTER 22: USING SIMPLE MACHINES (text pages 436-53)

• CONCEPTS AND KEY ACTIVITIES

1. *We can control energy and change its form.*

A relatively simple way to approach the concept is to ask why pupils eat food and how it helps their bodies. Elicit that food helps us (our body cells) perform useful activities or work.

Bring out that work is performed, according to the physicist, when a force moves an object. Is work done when green bodies are pushed along by the moving protoplasm of the cell? (Work = force multiplied by distance.)

Ask pupils to trace the chemical energy in the food they eat to the cells of the body, where it is converted to heat energy. Review the function of muscle cells. (The chemical or food energy the muscle cells receive is eventually converted to mechanical energy of motion.)

Demonstrating Different Forms of Energy. A committee can help prepare this demonstration by showing equipment associated with common forms of energy. For example, an ignited alcohol lamp (or gas burner) may be shown for heat energy, an electric spark from an induction coil for electrical energy, a burning match or lamp for light energy, an electric motor for mechanical energy, a candy bar or piece of wood for chemical energy, and a radium dial on a watch for atomic energy. Use the chalkboard to list these six forms of energy and have the class furnish additional examples.

Demonstrating Energy Changes from One Form to Another. Light an alcohol lamp to show the change from chemical energy to heat and light energy. Ask pupils to devise an additional demonstration to show how this heat energy can be used to move objects. Place a half ounce of water in a Pyrex test tube, cork loosely, and hold over the flame of the lamp, making certain the tube is pointed away from the class (or the teacher!). The heat energy becomes the mechanical energy of the steam which pushes the cork into the air.

Diagram on the chalkboard a summary of this demonstration, using various pupils as commentators:

$$\text{alcohol}\begin{pmatrix}\text{chemical}\\ \text{energy}\end{pmatrix} \rightarrow \begin{Bmatrix}\text{heat energy}\\ \text{light energy}\end{Bmatrix} \rightarrow \begin{pmatrix}\text{mechanical}\\ \text{energy}\end{pmatrix}$$

How can we get heat from mechanical energy? Pupils can rub their hands together or rub two coins together. Or use a hand drill on a piece of hard wood.

Elicit other forms of energy transformations:

1. *Mechanical to electrical*: Use a hand magneto.
2. *Mechanical to light*: Use a friction lighter.
3. *Heat to light*: Heat an iron nail to glowing.
4. *Heat to chemical*: Heat gently a mixture of glucose and Benedict's solution (note the reddish precipitate of cuprous oxide).
5. *Light to chemical*: Refer to photosynthesis. Also, fill two test tubes with a mixture of table salt solution and a silver nitrate solution. Note the precipitate of silver chloride in each. Place one tube in the dark; direct a beam of light

on the other. The exposed tube will turn dark within a class period.

Films. *Energy from the Sun* shows how man makes use of the sun's radiant energy. *The Nature of Energy* describes the position of atomic energy in relation to other forms of energy. Both films can be used for a review.

HELPING THE SLOW LEARNER

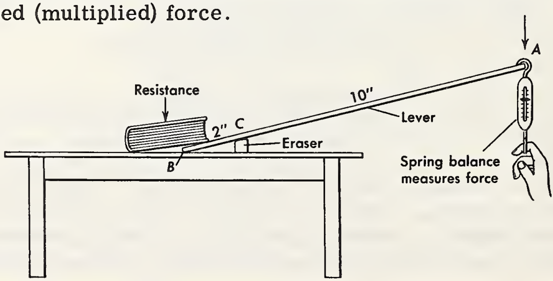
Have the slow learner calculate how much work he does when he lifts himself on the chinning bar a distance of two feet. Refer him to the text for a hint in solving the problem. What resistance did he have to overcome? (Gravity.) Problems of this simple type will give him an incentive to read the text in order to obtain clues.

2. *Simple machines like the lever, inclined plane, pulley, and screw, do work.*

Ideas for class discussion can follow the film, *Machines Do Work*, which presents an elementary description of simple machines. Also, *Simple Machines* shows and explains the six simple machines.

Another approach involves each student's working with a ruler, eraser, and a book. Follow the directions given on text page 442. Write the words *fulcrum*, *force*, and *resistance* on the board and have pupils develop diagrams with arrows to show several methods of lifting the book. Then go into the concept of simple machines, including *work*, *efficiency*, and *mechanical advantage*. Ask what we gain by using a lever to do work (such as lifting a book, a boulder, or prying a lid from a can). Some pupils may be ready to calculate the mechanical advantage of the lever system they are using (divide the distance from the force to the fulcrum by the distance from the resistance to the fulcrum; this disregards friction, of course).

Elicit the information that the advantage gain involved an increased (multiplied) force.



The lever system in the diagram has a mechanical advantage of 5 (10 inches divided by 2 inches). Pupils may have read that the work put into a machine equals the work done by the machine. A committee (or the entire class) can measure the work done at each end of the lever. A spring balance can be used to measure the force at *A* as well as to measure the force at *B* (the weight of the book). Committees can make different measurements: How much force is exerted at *A* in order to lift the book ½ inch? ¼ inch? 1 inch? Compare the distance moved by the force at *A* for each distance.

To find the work done at each end of the lever:

Work put in the lever (input):

Work	=	Force	×	Distance
at		at		moved
A		*A*		at *A*

Work done by the lever (output):

Work	=	Force	×	Distance
at		at		moved
B		*B*		at *B*

The force at *B* is the weight of the book.

Does the work put in at *A* equal the work put out by the lever at *B*? Have the pupils give suggestions (some of the missing work at *B* went into overcoming friction). Ask the class where else friction might use up some of the input work.

Field Trip. Divide into small committees to list evidences of simple machines used at or near the school. Have the members tabulate their data, giving the use and location of each machine. Report on the value or advantage of each: lever, inclined plane (including screw and wedge), wheels and axles, pulleys. If possible, ask some pupils to calculate the mechanical advantage (neglecting friction) of the inclined plane and the wheel and axle. They will have to read text page 449 for this activity.

Demonstrating a Simple Machine (the Pulley). Set up several pulleys in class. Use one which shows only a change in direction such as some pulleys on school shades (mechanical advantage of 1), and others of different numbers of fixed and movable pulleys. Develop the role of machines in modern living and how they help man in his work.

An Exhibit of Machines Used at Home. Have students bring in items of kitchenware which are actually simple machines (nutcracker, scissors, shears, egg beater, can opener, and a knife).

HELPING THE SLOW LEARNER

The slow learner can be on a committee to set up an exhibit of the six simple machines. Suggest he make individual charts (outline drawings) of these machines and include the main uses served by each.

If the school (or public) playground contains seesaws or teeterboards, the pupil can use a yardstick to measure where he and a friend have to sit in order to balance the board. Bring the data to class, together with the weights of his friend and himself. On the board diagram the information obtained. Encourage the class to come to some conclusions with regard to the work performed by each (for example, when both sat at opposite ends of the board, one of them rose into the air. Why? (Use the equation work = force × distance and establish that one pupil exerted a greater force than the other.)

HELPING THE RAPID LEARNER

See text page 453, which suggests a study of pulleys (exercise 3). The rapid learner can prepare the wooden frame and demonstrate the mechanical advantage of each pulley system.

Have him survey his home for examples of three kinds of levers. He can prepare an exhibit, or make outline drawings of these items: hammer, scissors, crowbar, etc. (fulcrum between force and resistance); wheelbarrow, nutcracker, bottle opener, etc. (resistance between force and fulcrum); baseball bat, tongs, broom, etc. (force between fulcrum and resistance). He can see that levers are used not only for gaining force but also for gaining (multiplying) distance while (in the case of a bat or racket) the force is reduced.

The chapter on machines in *The Physical World* will give added references and suggestions for projects.

CHAPTER 23: GETTING ENERGY FROM FUELS
(text pages 454-74)

• CONCEPTS AND KEY ACTIVITIES

1. *Fuels differ in the rate of burning and in the amount of heat energy they give off.*

You may approach this concept by referring to a true story of a tragic accident in which fire safety was disregarded. On a calm, warm day a short time ago a man raked dry leaves together and

prepared to ignite them. In order to speed up burning he saturated the pile of debris with gasoline. He stayed back a short distance and ignited a match with the intention of throwing it toward the gasoline-soaked leaves. Before he could do so, the gasoline fumes surrounding him exploded and he was burned fatally. Incidentally, the man was located at the bottom of a slight incline; the gasoline fumes rolled downward and engulfed him.

Ask pupils to comment on safety practices which were ignored. Others may cite further examples of careless habits with fuels around the home. Develop the ideas that fuels are used for different purposes, burn at different rates, and that some give off more heat than others. Continue into the concept.

Demonstrating How Fuels Burn. A pupil can place a glass lamp chimney over a candle. How long does the flame last? Now, allow some air to enter under the lamp chimney and have the class note the continued burning of the candle. Review the concept that fuels need oxygen in order to burn. Also, vary the air inlet of a Bunsen burner and show a very yellow flame.

Ask pupils how they go about igniting a camp fire. Develop the idea of igniting or kindling temperature. Heat $^1/_2$ cup of water in a plain paper cup. Ask the class why the paper failed to ignite (the water absorbs the heat energy from the flame so rapidly the kindling temperature is not reached). Encourage pupils to suggest a control: heat an empty paper cup over the flame. What happens?

Demonstrating Incomplete Combustion. Have a pupil hold a white plate over a burning candle. Have the class account for the accumulation of carbon. Close the air inlet of a Bunsen burner and repeat the procedure. Ask the class to suggest how the amount of unburned carbon can be reduced. Open the inlet port and note the blue flame. Try to collect carbon now. Have pupils compare the heat given off by the yellow flame with the heat of blue flame. Ask pupils how they would go about making this comparison. (Some may suggest heating a measured amount of water for a measured interval of time; others may suggest comparing the time it takes to bend a piece of soft glass tubing in the two flames.)

Is gasoline completely burned in an automobile engine? Stress the dangers of carbon monoxide—a product of incomplete combustion.

Films. *Fuels and Heat* is available either as a film or as a filmstrip. *Our Common Fuels* describes how man uses fuels. Each fuel is compared as to cost, convenience, and heat value. This film may be used to introduce the concept or to summarize it.

2. *Steam, gasoline, Diesel, and gas turbine engines burn fuel to do work.*

Start with a review of man's use of steam to do work. (Pupils may help you list such devices as the steam engine, the steam turbine in an atomic submarine, steam blasting the dirt off a wall, etc.)

Another approach is to use a toy steam engine (perhaps you may borrow one from a pupil). A working model may be purchased from one of the scientific supply houses listed on Manual page 225. Be sure to have pupils point out the location of the sliding valve and how it controls the entrance of steam into the cylinder. Discuss how steam does work. Then go into a discussion of different internal combustion engines.

Demonstrating the Force of Steam. Fill a test tube one quarter full of water as described on text page 472. Ask what made the cork fly out. (The expanding steam creates force sufficient to push the cork a distance.)

For the Bulletin Board. Perhaps a student who has access to the school shop (or a home workshop) can make a cutout model of a simple steam engine such as Watt's engine. He can use a plywood or cardboard base. By pasting strips of heavy cardboard, or strips of narrow plywood, he can demonstrate the moving piston, slide valve, and turning flywheel.

Demonstrating a Model of a Gasoline Engine. A committee may construct a large cutaway model of a gasoline engine. Use the diagrams in Fig. 249 (text page 465) as guides. Strips of plywood or plastic may be formed to approximate the outline of the diagram. The strips can be about $\frac{1}{2}$ inch high and glued or nailed to the board. Demonstrate the four strokes of the gasoline engine by moving the piston by hand and opening the intake and exhaust valves at the appropriate time. Some pupils use an attached flashlight bulb as a simulated electric spark to set off the power stroke.

Demonstrating the Efficiency of Electric Motors. Several pupils may engage in the activity described on text pages 469-70 and calculate their horsepower. Then they can collect data on the horsepower of different electric motors (at home, at school, etc.). A simple mathematical activity by the committee can result in a table of efficiency ratings of various electric motors.

Tell the pupils that 1 horsepower equals 746 watts. Then they can find the efficiency of any electric motor by comparing the number of watts the motor uses with the horsepower label on the motor. If a motor uses 500 watts (according to the label inscription), it uses $\frac{500}{746}$ of one horsepower. If the motor develops $\frac{1}{3}$ horsepower as indicated on the motor, the efficiency is $\frac{1}{3}$ divided by $\frac{500}{746}$. Which motor was most efficient?

Films and Filmstrips. The Harbrace filmstrip *Energy Unlimited* shows a sequence of frames on the gasoline engine,

which can be projected when pupils are ready to consider how the linear or straight-line motion of the piston is translated to rotary motion (by the action of the connecting rod against the bend in the crankshaft).

Several free films are available, such as *The Diesel Story*, which presents a historical development, and *The ABC of Internal Combustion*, which discusses the importance of air, fuel, and ignition in the creation of power.

Readings. Many automobile companies will provide class sets of booklets with such titles as *The Story of Combustion* (describes the internal combustion engine); *The Power Primer* (automobile, Diesel, and aircraft engines); *The Story of Power* (describes the transmission of power). A chart of a Diesel cycle is available. See the listing on Manual page 223 for General Motors Corporation.

HELPING THE SLOW LEARNER

A simpler text such as Zim's *What's Inside of Engines?* may help the poor reader do some independent reading. Gasoline, steam, jet engines, rockets, and an atomic pile are all included in this elementary book.

More Power To You is a simple presentation of the development and use of power.

The slow learner may want to construct a simple model of a steam turbine by placing a pin hole near the top of a one-gallon can which has been ⅛ filled with water and firmly corked. Mount a metal disk (cut from a tin can) with serrated, bent edges in front of the expanding jet of steam and watch it turn. Can he criticize the use of such an engine in industry? (Much of the steam jet is wasted, and the blast tends to tear the blade from the mounting.) The can of water can be heated over a hot plate. Make certain the container has been rinsed well, especially if it has held combustible fluids. See text page 472 for additional directions in cutting out the metal blade.

HELPING THE RAPID LEARNER

The science-prone child usually delights in the construction of a working model of such devices as engines. *The Boys' Book of Engines, Motors, and Turbines* gives simple construction ideas for all types of engines, from early steam to electric. Or he may care to read Willy Ley's *Engineers' Dreams*, which gives a vivid presentation of future sources of power.

If he is a model-airplane hobbyist, have him disassemble a model airplane engine, and pass the piston, connecting rod, and crankshaft around the classroom for each pupil to observe. He may then be able to lead a short discussion on the use of each part.

Or suggest he read some of the references listed on text pages 473-74.

CHAPTER 24: HARNESSING THE ELECTRON
(text pages 475-501)

• CONCEPTS AND KEY ACTIVITIES

1. *Static and current electricity can be produced in different ways; electric current is a flow of electrons.*

One way to start is to ask how many in the class have received a mild shock when they touched the door handle of an automobile. Develop the idea that sliding along the car seat (friction) results in the build-up of an electrical charge. Some pupils may describe what happens when they walk on a wool rug and then touch an object. Then discuss negative and positive electrical charges.

Have pupils rub a fountain pen or a comb against their hair and then try to pick up bits of paper with it. Elicit that electrons (negative charges) have migrated from the hair to the comb or fountain pen. These extra electrons in the comb or pen result in the negative charge. At this stage you may find it advisable to refer to Fig. 253 to elucidate loss and gain of electrons. Better still, have pupils demonstrate the simple activities in the diagram and suggest to them that friction between two types of certain materials places a positive charge on one material and a negative charge on the other. Also, like charges on two objects cause them to repel each other, whereas unlike charges cause them to attract each other.

Students may wonder about the bits of paper which have neither a negative nor a positive charge. The negatively charged comb when brought near the paper causes some of the electrons in the paper to shift to the other edge of the paper. A positive charge results on the edge nearest the comb, and the paper is attracted.

Constructing and Demonstrating an Electroscope. This simple device can be used to discover with which kind of charge you are dealing. One or more electroscopes can be made as student projects and used for class demonstrations or group experiments. A screw-top glass container can be used as the shell of the instrument. Cut a hole in the lid large enough to hold a one-hole rubber stopper. Insert a nail through the stopper (insulator) so that the point is well into the jar. Two thin strips of aluminum foil, about ½" by 2", can be cemented or tied by their upper ends to the lower end of the nail. Pupils can experiment with such objects as a

positively charged glass rod (compare with Fig. 253) placed against the head of the nail. Observe the foil leaves springing apart. A second like charge brought to the nail will cause the leaves to diverge further. An opposite charge or grounding will cause the leaves to collapse.

Ask pupils to try charging such materials as glass, Lucite, a hard rubber comb, or a film negative by rubbing each of them with a piece of fur, wool, nylon, silk, or cotton. With the electroscope determine what type of charge has been placed on the materials.

For the Bulletin Board. A committee can assemble photographs and clippings picturing accidents caused by sparks from static electricity. Also, photographs and lists of preventive measures can be assembled. Use these items to lead off a discussion of danger from sparks in hospital operating rooms, on gasoline trucks, in coal mines, and in flour mills.

Demonstrating the Parts of a Dry Cell. Have pupils bring in old dry cells. Arrange for some to be cut crosswise; others, lengthwise. Use Fig. 255 as a reference.

Demonstrating the Effect of an Electric Current. Let pupils have an opportunity to examine an active dry cell (1.5 volts). Pour two tablespoons of vinegar into a tumbler half filled with water. Place wires from each cell terminal into the dilute vinegar. The wire connected to the negative or zinc pole will soon show many bubbles on its submerged end. The negative pole is the source of electrons or negative charges. The electrons flow by way of the wire through the solution and back to the positive pole of the cell. As the current passed through the acid solution, hydrogen was released as bubbles and collected on the submerged end of the wire.

Demonstrating the Parts of a Storage Battery. Obtain a discarded automobile storage battery from a local garage. Make certain all sulfuric acid has been removed; wash and dry the battery thoroughly and dissect a corner of it with a hacksaw.

Films. You may wish to review static electricity with the film *Electrostatics*, which describes how to produce, measure, and use static electricity. *Introduction to Electricity*, a color film, gives many examples to deepen appreciation of the importance of electricity, in addition to explaining terms and fundamental concepts. A free loan film, *Story of the Storage Battery*, is available from the U.S. Bureau of Mines; it illustrates principles of operation, applications, and care.

HELPING THE SLOW LEARNER

Simple experiences with static electricity will help to evoke and sustain interest. Suggest the pupil blow up several balloons, rub each of them on his sleeve (or hair), and bring them near a

wall. A dry day will produce good results, with the balloons clinging to the wall for some time. Damp air allows the charge to be carried away sooner.

The slow learner can get a better idea of how like-charged objects repel each other by bringing two similarly charged balloons together. Or he can rub his comb rapidly through his hair and then bring it near a thin stream of running water from a faucet. The charged comb will attract the stream of water toward it.

Suggest he charge his hair by running a comb rapidly through it. Electrons will be removed from the hair, leaving each hair with a positive charge. Some of the hairs will stand on end as the similarly charged strands repel each other. Have him bring the negatively charged comb a short distance above his head. Elicit an explanation for the attraction of strands of hair (positively charged) for the comb. (Unlike charges attract each other.)

2. *Some generators of electricity depend on the connection between magnetism and electricity.*

3. *We use electricity for lighting, heating, power, and for other purposes.*

You may want to determine the background your pupils possess on simple principles of magnetism and electricity. A pre-test will often furnish a useful clue and determine your method of introducing the concept.

Students are usually interested in experiments with magnets. A class set of inexpensive bar magnets obtained from a scientific supply house will allow for individual observations and further explorations. Interest may be aroused by demonstrating toys making use of magnets. Or you may begin discussion by demonstrating bar magnets suspended by strings. Call on students to place the north pole of a magnet near one end of a suspended magnet. Ask the class to suggest an explanation of the action, as well as to suggest further procedures (such as placing the north pole of the magnet near the opposite pole of this suspended magnet). Bring out that like poles repel each other and opposite poles attract each other. Explain that "north" stands for "north-pointing" pole.

Demonstrating the Making of a Magnet. Refer to text page 484 for directions for making a magnet from a steel darning needle. Then develop a discussion on uses of a compass.

Demonstrating Magnetism from Electricity. If twelve to fifteen dry cells of 1.5 volts each can be accumulated, they will provide an excellent opportunity for small committee investigations. Divide the class into groups of two to three pupils each. Each group can make an electromagnet by winding half of a five-foot length of bell

wire around a large iron nail. Attach one end of the wire to a dry cell terminal and the other end to a terminal on a simple switch (this can be omitted if you wish). Join the other terminal of the battery and the other terminal of the switch with a one-foot length of wire.

Press the switch to close the circuit and test the attracting power of the nail by bringing it close to a pile of paper clips. Open the switch and have the committees make observations and further suggestions for investigations.

Encourage a study of relationships between number of wire turns and number of paper clips picked up by the electromagnet. Also, allow the groups to share additional batteries (hooked up in series) and determine how these additional dry cells affect the strength of the magnet. Develop a discussion on the uses of electromagnets in industry and at home (bells, motors, and buzzers). Refer to the photograph (Fig. 261) of the electromagnet.

Demonstrating Electricity from Magnetism. Make a wire coil by winding one half of a five-foot length of bell wire around an empty cardboard spool or a cylindrical can. (A frozen fruit juice can makes a good base.) Remove the coil and connect the ends of the wire to a galvanometer (or place the wire from the coil over the face of a compass and join the ends of the wire to complete the circuit). The compass needle (or the regular galvanometer needle) should shift once when a bar magnet (make certain that it is not too close to the compass) is thrust into the coil, and again in the opposite direction when the magnet is withdrawn. From this, go into a discussion of Faraday's discovery that magnetism can be used to make electricity.

Field Trip. A field trip to an electric power plant may serve to introduce the topic of electricity, or to review it. If there is an electric power plant near you, write or telephone for permission to visit. Be sure to state the background level of the class and the purpose of the trip. Your guide can then phrase his comments in simple phrases. It is possible that a pupil may have visited a huge power plant such as Hoover Dam. Have him describe his visit and bring any literature he may have accumulated. Or write to Hoover Dam (Boulder City, Nevada) for free descriptive folders of the plant's history and operation.

For the Bulletin Board. Preparation of a display of pictures and diagrams of important hydroelectric plants in the United States makes an interesting project. Have a committee write to the Bureau of Reclamation, U.S. Department of the Interior, Washington, D.C., for descriptive folders. The Bureau will send you the folders distributed to visitors at these dams. Perhaps you may wish to suggest a joint project with the social studies teacher.

Demonstrating the Electric Meter. A good way to discuss watts and kilowatts, which measure electric power, is to have as many

pupils as possible bring in family electric bills. Perhaps a partially dissected demonstration electric meter can be borrowed from a power company. Suggest each pupil compute the cost for electric power, and check accuracy of calculations from his bill. Figure 266 can be used for reference, if no meter is available. Make a large replica of the meter's face on the chalkboard.

Demonstrating Electrical Connections. Have a committee fasten five miniature lamp sockets about two inches apart on a wooden board. Insert flashlight bulbs and wire the sockets in series; then, wire them in parallel. One or more 1.5-volt dry cells can serve as the source of electricity. What happens when one bulb is removed in a series connection; in a parallel connection? The committee can demonstrate the results. You may wish to refer to Fig. 267, which reviews electrical connections.

A Class Report. Students can make reports on the following electrical units and on the scientists from whose names they were derived: ampere, volt (Volta), ohm, watt. What significant contributions did each man make?

Demonstrating the Parts of an Electric Motor. Local hobby stores may sell simple electric motor kits. An excellent kit which sells for 25 cents (cheaper on a quantity purchase) includes concise directions for assembly on its cardboard container by means of wire clips. Write to G. W. Moore, Inc., 100 Beaver Street, Waltham, Massachusetts.

This motor runs on direct current obtained from a 1.5-volt dry cell. Encourage pupils to identify and understand the function of the field magnet (a fixed electromagnet) and the armature (an electromagnet on the rotating shaft of the motor). How is the electric motor the reverse of the electric generator? Suggest pupils explore this question by group discussion, reading references, and chalkboard summaries. (In the motor, electricity produces motion; whereas in the electric generator, motion produces electricity.)

Surveying Home Uses of Electricity. Have pupils list electrical devices under such headings as: heating, lighting, sound producing, motion producers.

Films and Filmstrips. The film *Making Electricity* explains how electricity is made, from the hand-operated generator to the great hydroelectric plants. The last half of the Harbrace filmstrip *Energy Unlimited* can be used to introduce the principle of the magneto (in this case a hand generator is shown). Free loan films on the subject of electricity are listed on Manual page 153.

HELPING THE SLOW LEARNER

One way to arouse interest among the science-shy is by using blueprints to record permanent records on magnetism observations. The diagrams of magnetic lines of force shown in Fig. 258 are

helpful references. Substitute slow-acting blueprint paper and (for support) place over a cardboard which has been placed, in turn, over a bar magnet. From a salt shaker sprinkle fine iron filings over the cardboard. (Iron filings may be obtained from a scientific supply house; homemade iron filings are often jagged and dangerous.) If desirable, tap the cardboard gently. Allow the bright sun to bathe the paper for about a minute; remove the blueprint paper and wash in a jar of tap water to which has been added 3 to 4 tablespoons of 3% hydrogen peroxide. Repeat with two magnets, as shown in Fig. 258.

The slow pupil who has reading problems may find S. and B. Epstein's *The First Book of Electricity* fascinating. The simple text and illustrations include directions for construction of an eleven-cent battery and a telegraph set.

HELPING THE RAPID LEARNER

One way to show the rapid learner that he can play a fundamental role in class is by encouraging him to seek ways of *helping you* provide materials for class demonstrations.

For example, he can make a demonstration lead storage cell by inserting two strips of lead into a dilute solution of sulfuric acid. Connect each strip to opposite terminals of a 6-volt battery (or wire up four 1.5-volt cells). After a short interval, disconnect the wires from the battery and try to ring a bell or light a flashlight bulb with the demonstration cell. Suggest that he look up the explanation for the brown coating (lead dioxide) formed on one of the lead strips.

He can write for free booklets such as *Electrical Fundamentals*; also, *Magnetism and Electricity* (both obtainable from the Chrysler Corporation). The former goes into the basic considerations of Ohm's Law, while the latter covers the induction of an electric current in a coil.

Directions for building an electric motor are given in a free booklet distributed by the Westinghouse Electric Corporation. Let him explain the motor's operation to the class.

He will enjoy *All About Electricity*, by I. M. Freeman, and perhaps want to try some of the suggested experiences.

He may investigate Ohm's Law and illustrate the principle that current varies directly with the voltage and inversely with the resistance. $\text{I (Amperes)} = \frac{\text{E (Volts)}}{\text{R (Ohms)}}$

He can pass current from three 1.5-volt dry cells in series through 25 feet of #18 copper wire and place an ammeter in series with the wire. Read the current (in amperes) and then pass the current through 50 feet of #18 wire. Compare the new reading with the previous one. Then substitute #28 wire, which is smaller

in diameter. How do length and cross-sectional area affect the resistance of wire and therefore the amount of current flowing through the wire?

Another direction for his investigation of Ohm's Law is to compare the resistances of various electrical appliances at home. For example, examine an electric iron designed for an A. C. circuit of 110 volts. Some appliances show the number of ohms. He can determine the amperage (if the resistance is not given) by noting the number of watts stamped on the appliance's name plate (Volts × Amperes = Watts; or Amperes = $\frac{\text{Watts}}{\text{Volts}}$). Then he can calculate the resistance in ohms by substituting the equation: $R = \frac{E}{I}$.

CHAPTER 25: MODERN PACK HORSES
(text pages 502-27)

• CONCEPTS AND KEY ACTIVITIES

1. *The automobile is our most common form of transportation.*

Start discussion on different forms of land transportation. List these on the chalkboard and develop the idea that the "horseless carriage" or automobile changed our way of living. How do we use the automobile in our daily living? Then go into safety factors in the operation of the automobile. Follow up with functions of the main parts of the vehicle.

Another approach can make use of the bicycle as a means of transportation. How does it show similarities to the automobile in its operation? Ask a pupil to bring his bicycle to the classroom. Make a mark on the gear to which the foot pedal is attached (a small piece of masking tape is a good marker). Place a similar mark on the small gear. When the chain from the large gear turns the rear or small gear, have a pupil count the number of times this small gear revolves while the large gear makes one revolution. Or you may have the class note a chalk mark on the rear tire. While the bicycle is on its stand, have the pupil slowly turn the large gear attached to the pedal until it makes one complete turn. In the meantime, the class can note the number of turns the rear wheel makes. Discuss the advantages of using different-sized gears in an automobile transmission to give different speeds.

Demonstrating an Automobile Transmission. Use free charts from the General Motors Corporation, such as *Three-Speed*

Gear Transmission and *Typical Gear Transmissions.* If the school has an automobile shop, you may demonstrate the clutch and transmission system. Lead into discussion of the use man makes of complex machines such as the bus, truck, and automobile.

Field Trip. If there are no facilities for auto repair on the school grounds, arrange a short inspection trip to a local automobile repair shop. Make certain the mechanic does not become too technical in his explanations. Pupils can prepare a list of questions beforehand.

For the Bulletin Board. Post clippings of automobile accidents under such headings as: man's carelessness; defective parts (such as blowout of a tire); weather conditions, etc. Discuss ways of cutting down accidents.

Films. You may begin the topic with a free animated film, *The A.B.C. of the Automobile Engine,* which deals with the workings of the power plant of a car. If there is strong interest in the topic, try showing them *Automatic Transmissions.*

HELPING THE SLOW LEARNER

The slow pupil may have an interest in automobiles, ranging from building plastic models from a kit to working after school on his friend's jalopy. Encourage him to bring his model cars to class and set up a historical sequence of types of automobiles.

Send for a class set of *Evolution of the Automobile,* which tells the history of automobile development.

Or have the slow learner construct cardboard or plywood gears according to the directions under Fig. 274.

2. *Modern ships and airplanes provide safe, rapid transportation.*

Pupils can assemble pictures of various types of ships, from tugboats designed for force to ocean-going liners designed for speed, space, and passenger comfort. Others can bring in ship models they have constructed. Go into the principles of flotation and water pressure. Perhaps pupil committees can help present simple demonstrations of water pressure as a review.

Demonstrating Flotation. A pupil can fold a piece of aluminum foil into the shape of a small boat and roll another piece of the same size into a ball. Place both in a large glass jar of water. Ask why the boat floats.

Prepare an overflow container by heating a large nail and melting a round hole in a transparent plastic box (an empty potato salad or ice cream container) about one inch below the top. Insert a two-inch length of rubber tubing into the opening. A pupil can weigh a small stone in air with a spring balance and

then weigh it while it is submerged in water that has been brought to the level of the overflow spout. Catch the water in a beaker and weigh it. Have the class explain what they observe. Discuss why some objects float and others sink.

Demonstrating the Pressure of Water. Prepare a J-tube by attaching a length of plastic tubing (obtain in a pet store) to the side of a carton. Add a small amount of red ink to this manometer and place a 12-inch ruler alongside the upright longer tube. With a red-hot nail pierce a hole through the bottom (center) of a pint plastic container. Attach one end of an 18" piece of rubber tubing to this opening. The other end of the tube is attached to the manometer tube. Place a rubber sheet across the mouth of the container and hold in place with rubber bands. Fill a large aquarium tank with water, place the container in it, and allow different pupils to note the pressure of the water on the rubber diaphragm. Vary the position of the container. Pupils can explain how we use air pressure changes to measure water pressure changes.

For the Bulletin Board. A committee can post pictures of airplanes, including experimental types. Or they can prepare a history of aircraft, in pictures, for display. A diagram of the parts of an airplane can occupy the center of either display.

Films. You can show the principles of lift, stability, thrust, and drag with the free film *How the Airplane Flies.* You may have pupils demonstrate how increased air speed causes reduced pressure. Hold a sheet of paper in front of you and blow gently over the top surface. Repeat, but this time blow harder. What made the paper rise? (Greater air pressure under the paper.) Interrupt the film from time to time to encourage questions and stimulate further thinking.

Jet Power and *Jet Propulsion* are two other free films which trace the development of the jet engine and describe its basic operation.

Readings. You may supplement the films with a class set of the free booklet *Adventures in Jet Power.* The Civil Aeronautics Board in your area may be able to furnish additional booklets. A free chart of a turbojet engine may be obtained from Westinghouse.

The *Story of Flight* is an easy-to-read account of the development of the airplane. *Rockets and Jets* tells the story of jet and rocket engines.

Field Trip. Visit a local military or civil airfield. Prepare in advance a series of questions raised by the pupils. What safety precautions are taken before and after take off, before and after landing? A photographic record of the trip will supply material for an exhibit.

As pupils examine types of planes, including jets, have them bear in mind the forces of thrust, lift, drag, and weight which act

on a plane in flight. Note the dihedral angle of the wings (furnishes automatic lateral control), which results in a tilted V-form.

Demonstrating Action and Reaction. A pupil may demonstrate the principle of the jet engine by gluing a small rubber balloon to a small toy plane (or car); have the mouth of the balloon face to the rear. Inflate and release the balloon. Or punch a row of holes around the bottom end of a metal coffee can. Punch the holes at an angle with a nail so they all point in one direction and suspend the can by a cord over a large surface basin or sink. Now pour water into the coffee can. Notice the rotating motion as water is forced out from the holes. The water flows in one direction; the can moves in the opposite direction. Elicit an explanation and compare with the construction of jet planes and rockets.

Making a Collection of Model Planes. Beginning on page 527, directions are given for developing a model airplane hobby. Inexpensive kits of prefabricated plastic parts are available in many toy stores. Some pupils may be ready to organize an exhibit of different types of jet planes, helicopters, and propeller-driven planes.

Ask students to attach colored strings from parts of the exhibited airplane to captions naming the part and telling how the part influences the plane's flight, etc. How is air friction (drag) reduced on this specific model? (Careful streamlining.) How does the research scientist make use of plane models? (He studies them in wind tunnels, etc.)

HELPING THE SLOW LEARNER

A simple demonstration may enable the slow learner better to understand the principle that increased air speed causes reduced air pressure. He may perform it either at home or in class by holding a sheet of paper and blowing over the top surface so that it will lift upward. Or he can suspend two apples (or Ping-pong balls) about one to two inches apart and, with a straw or glass tube, blow between them. Why do they bump together?

This may be a good time to refer to the diagrams of air flow around an airplane's wing (text page 516). Have the student measure the length of the upper wing surface in the figure; also, the length of the lower wing surface. Elicit that the air currents over the wing have to travel a longer distance. Therefore they travel faster in the same time than the air currents under the wing, creating greater pressure below the wing.

Airplane companies will send free literature and pictures which are helpful for the slow reader and other pupils. Consult the nearest regional airport offices. Regional Civil Aeronautics Administration offices may be willing to conduct trips to air facilities, provide materials about aviation, and send a speaker to your school.

Experiments with Airplane Instruments, simply written and well illustrated, contains descriptions of airplane parts and simple experiments which show the principles of their operation.

The Golden Book of Airplanes includes many large illustrations and simplified text.

HELPING THE RAPID LEARNER

The science-prone child delights in model airplane construction. Perhaps he has built or is interested in building engine-powered, free-flying models or those which can be radio controlled. Have him bring his plane to class and explain details. Some of the references on text page 530 will be helpful to him.

If he is interested in automobiles, have him draw his impression of how an automobile of the future might look. He can use what he knows about present trends in power, size, speed, etc. What safety devices would he include in this model? Some automobile companies welcome letters and inquiries from youngsters with these interests.

He can interview an experienced automobile mechanic and gather information on how present cars differ from cars of former years.

He can write for *The Power Primer*, free from the General Motors Educational Service and which summarizes the main ideas. Why not have him adapt some of the colorful illustrations for a report on the internal-combustion engine? Similarly, *Power Goes to Work*, from the same source, shows how gears, transmissions, and propellers work in cars, boats, and planes. On school stationery request enough copies for class use.

The teacher can receive a free subscription to *Skylights*, a monthly fact sheet issued by the Materials of Instruction Committee of the National Aviation Education Council, 1025 Connecticut Avenue, N.W., Washington 6, D.C. For instance, the February 1959 issue contains a photograph of a cutaway model of a satellite capsule designed to carry man into orbit around the earth. The science-prone student may be interested enough in such topics to want to do more detailed reading. In each issue, there is a bibliography of interest to him and mention of free materials.

SUMMARY AND USE OF TESTS

Power units in both automobiles and jet planes arouse the interest of pupils of different ability levels. How aeronautical engineers, and others, have helped solve such problems of high-altitude flight as the sound and heat barriers are good sources for reports. A visit to a testing laboratory—or a film—can go a long way toward enriching a lesson, by showing the use of models for the practical

purpose of testing. Such devices help fire the imagination. Again, as with other topics in science, students will realize that such modern means of communication as the radio, television, and the printed word will bring information about future advances in machines and power units.

Harbrace Teaching Tests to accompany *You and Science* consist of two 112-page booklets of objective-type tests, Forms A and B. Chapter tests and a unit test are found in each booklet.

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4. *Skylights,* a monthly fact sheet on aviation for teachers. Have your name placed on the free mailing list; write National Aviation Educational Council, 1025 Connecticut Ave., N.W., Washington 6, D.C.

5. *Three-Speed Gear Transmission* and *Typical Gear Transmissions,* free charts from General Motors.
6. *Turbojet Engine,* free chart from Westinghouse.

MODEL AIRPLANES AS A HOBBY
(text pages 527-31)

As already indicated, reference to model airplanes and jets is a wonderful motivation for several sections of this unit. All categories of pupils are drawn to them. You can point out that the armed forces and civilian airlines have found airplane models extremely helpful both in demonstrating the principles of flight and in aircraft identification.

Simple model kits from the glider shown on text page 531, to complicated gasoline-powered planes, are available. References for both beginner and advanced beginner are listed on page 530. The rapid learner will find *The Model Aircraft Handbook*, 4th Edition, by William Winter (Crowell, 1957), very handy. If the bright child shows a flare for electronics, he can combine this interest in the construction of radio-controlled models. Full details and diagrams are given in Winter's book.

For the average student, and for some science-shy children who have normal muscular co-ordination, simple plastic assembly kits can be purchased in hobby shops and toy stores. A flying jet model, the Dynajet, has been available for many years. A single moving part, a thin sheet-metal valve, opens and closes as a blast of air opens the valve, pulling in fuel. The spark plug fires the gasoline-air mixture, and the force of the explosion closes the valve and drives the plane forward.

The hobbyist will find flying scale designs published in model airplane magazines. Full-size plans are often available at a nominal price from publishers of these magazines.

One way of introducing this hobby is to have a pupil enthusiast bring in his collection and demonstrate the flight of one of his models on the school grounds. Also, a visit to a model airplane contest is a thrilling event to the novice. The hobbyist can then lead class discussion.

UNIT 8

Speeding Communication

GENERAL THEME: *Scientists have found ways of using various kinds of waves to extend man's ability to hear and see.*

The pupil investigates the many recent discoveries that make use of sound and electromagnetic waves for better hearing and seeing. He finds out how his ears receive sound waves and his brain interprets them; and he realizes how fast sound waves travel and how waves can be made to differ in frequency (pitch) and amplitude (loudness) (text pages 534-46).

Next, the student studies his eye structure (pages 554-56) to find out how he sees. He begins to understand how and why he should protect his eyes. He is introduced to the science of light—the breaking up of white light into colors (spectrum), the effects of diffusion and glare, and how lenses (eyeglasses) can correct faulty vision (pages 548-58).

Now the pupil is ready to learn how science has extended his ability to see and hear. He examines how electricity makes the telegraph and telephone work and how they offer him communication with distant places (pages 561-65).

To complete his knowledge of moving and talking images, he studies how sound and light signals can be stored, resulting in talking motion pictures and sound recordings (pages 566-77).

To further extend his knowledge, the child is given suggestions for developing a hobby such as photography (pages 580-85).

He then sees how energy, traveling in waves, is able to cause electronic and magnetic effects (pages 586-605). Finally, he is shown how radio and television operate and how radar is used to "see" objects and to control the flight of airplanes (pages 606-24).

The Unit Inventory. Before beginning this unit, it is suggested that the pupils test themselves on how much they know about speeding communication by answering the questions on text page 532. In this way, you and they will be better able to plan the amount of time needed for study of certain topics to develop the concepts of this unit.

PLANNING AHEAD

So that you may plan in advance for a particular film or filmstrip, assemble needed equipment, or arrange a special program, the following items are listed for your convenience in the order mention is made of them in this unit. A more complete list of films, arranged by topics, appears on Manual page 202.

FILMS AND FILMSTRIPS

f = film c = color fs = filmstrip

Chapter 26

1. *Ears and Hearing* (f), EBF, 1950.
2. *Sound Waves and Their Sources* (f), EBF, 1950. Discusses oscilloscope patterns and the speed and transmission of sound.

Chapter 27

1. *Eyes and Their Care* (f), EBF, 1941.
2. *How the Eye Functions* (f), Knowledge Builders, 1940.
3. *Light* (fs,c), YAF, 1952.
4. *Light Control Through Polarization* (f), Polaroid, 1946.
5. *Light Waves and Their Uses* (f), EBF, 1937.
6. *Your Eyes at Work* (fs,c), Jam Handy, 1950.

Chapter 28

1. *Calling Your Neighbor* (fs,c), Harbrace, 1957.
2. *Electromagnets* (f and fs,c), YAF, 1949.
3. *Dialing the Nation* (f), Bell Telephone, rev. 1955, free loan.
4. *Highways for the Telephone* (f), Bell Telephone, rev. 1955, free loan.

Photography as a Hobby

1. *Behind Your Snapshot* (f,c), Eastman Kodak, free loan.
2. *Sound Recording and Reproduction* (f), EBF, 1943.

Chapter 29

1. *Curves of Color* (f,c), General Electric, 1941, free loan.
2. *The Strange Case of the Cosmic Ray* (f,c), Bell Telephone, 1957, free loan.

Chapter 30

1. *Bottle of Magic* (f), Western Electric, 1948, free loan.
2. *Calling Your Neighbor* (fs,c), Harbrace, 1957.
3. *Magic in the Air* (f), General Motors, 1949, free loan.
4. *Safe Passage* (f,c), Raytheon, 1955, free loan.
5. *Sentinel in the Sky* (f,c), Pan Am. Airways, 1955, free loan.
6. *Sightseeing at Home* (f), General Electric, free loan.
7. *The Story of Television* (f), DuMont, 1954, free loan.
8. *Vacuum Tubes* (f), EBF, 1943.

EQUIPMENT FOR DEMONSTRATION AND EXPERIMENT

Chapter 26

ear chart, 18" rubber tubing, flower pot, rubber sheet, electric buzzer, alarm clock, bell jar, exhaust pump, acoustic board, old automobile

muffler, 12" ruler, pop bottle, oscilloscope, tuning forks, tall glass cylinder, 8 glass tumblers, string, cardboard cups

Chapter 27

glass prisms, rope, frame of slats, Polaroid filters, blueprint paper, 250-watt bulb, cow's eye, eye model, Snellen Eye Chart

Chapter 28

model of telegraph set and receiver, bell, buzzer, gong, 1.5-volt dry cell, bell wire, switch, dry cell carbon rods, cardboard tube, copper foil, thin sheet metal, old telephone parts, 24" plastic-coated wire, 4" nail, tacks or paper clips, box camera (or other type), Kodak Velite paper, Tri-Chem packet, 8-oz. glass container, 8-oz. trays (3), 5" × 7" glass plate, 150-watt bulb, piece of 16-mm. sound film, tape recorder, portable record player (variable speeds), waxed paper, magnetized needle, photo-electric cell

Chapter 29

chart of electromagnetic spectrum (Westinghouse), 2" × 2" slide projector, spectroscope, X-ray photographs, ultraviolet lamp

Chapter 30

transformer, small lamp and receptacle, triode tube, dual diode tube, copper and iron wire, galvanometer, Bunsen burner

FIELD TRIPS TO BE ARRANGED

Visits to a commercial telegraph office, a teletype unit (pupil committee), a local broadcasting company, a local police radio transmitter, a local amateur radio operator (committee), a TV studio, a closed-circuit TV installation

CHAPTER 26: SOUND AND HEARING
(text pages 534-46)

• CONCEPTS AND KEY ACTIVITIES

1. *The ear receives sound waves and the brain interprets them.*

Ask pupils to name as many sounds as they can. Listen for sounds in the classroom; sounds from the street. How is our ear adapted to receive sound? Would a native from a primitive country respond to the same sounds as you? Explain. From this go on to the parts of the ear and develop the idea that the ear not

only receives, but transmits sound to the brain by way of nerves.

Or you may approach the topic by asking a pupil to read sentences from a book in an even tone. Have the rest of the class cover one ear, then the other, and finally both ears. Perhaps the school nurse has an audiometer which you may use. Pupils can be asked to account for variations in results. They may recall that a part of the ear has been damaged by injury or infection, thus cutting down on the reception of sound waves. Use a large diagram of the ear similar to the one on text page 535 to point out some of these parts.

For the Bulletin Board. Display pictures which represent surroundings hazardous to a person's ears (extreme pressures as in underwater scenes; a drawing showing a child placing an object in his ear canal; a person working near a jet engine). Captions suggesting how people exposed to these conditions can protect their hearing can be added.

Demonstrating a Model of an Eardrum. Jam one end of an 18" rubber tube into the drainage opening of a flower pot and cover the top of the pot with a rubber sheet. A student can blow air into the tube and the class will note the outward bulge of the "drum." Now have him inhale and note the effects on the sheet. You may wish to review the effects of air pressure differences on both sides of the ear drum. Elicit by questions the idea that a safety tube (Eustachian tube) can help maintain the same air pressure on both sides of the eardrum. Ask pupils to cite instances of eardrum discomfort. For example, a person with a bad cold who experiences discomfort when flying in an airplane without a pressurized cabin may have an obstructed Eustachian tube.

Film. Ears and Hearing or *Sound Waves and Their Sources* may be used as approaches to the concept.

Readings. After an approach which makes your pupils want more details about the structure and care of the ear, try a supervised reading lesson. Sets of free booklets about the ear are available from leading health agencies or insurance companies.

HELPING THE SLOW LEARNER

Sound: An Experiment Book contains simple activities with making and listening to sounds. Another easy book for the pupil with reading difficulties is *The True Book of Sounds We Hear*; it discusses common sounds and their causes.

2. *Sound waves travel at different speeds and vary in their pitch and loudness.*

Pupils may have read about the sound-detecting equipment used on ships for locating submarines (by reflected sound) and

for detecting ocean depths. Develop the idea that sound travels faster in water (4,700 feet per second) than in air (1,100 feet per second). Go on to consideration of sound vibrations as actually being sound waves.

Demonstrating That Sound Travels in a Medium. Set off a buzzer or an alarm clock in class. Then cover it with a bell jar and listen for the sound. Evacuate the air from the jar and note the difference. Following the suggestion on text page 538, have the pupils place themselves two feet apart in a long line. Each student represents a molecule of air which collides with the air molecule ahead of it and returns to its original position. Ask why no sound was heard in the vacuum. (No molecules of air to vibrate back and forth.)

Measuring the Speed of Sound in Air. If there is a high wall or cliff near the school, use a stop watch to note the time it takes for a sound to echo. Measure the distance to the wall or cliff if this distance is not known and double it, because the stop-watch measures the time for the sound to go and return. Explain that speed is measured in units of distance and time (for example, a speed of thirty miles per hour). Show a sample calculation of the speed of sound if a person were 2,200 feet from the cliff or wall and it took him 4 seconds to hear the echo:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{2{,}200 + 2{,}200}{4} = \frac{4{,}400}{4} = 1{,}100 \text{ feet per second.}$$

Now have the pupils calculate the speed from their stop watch record and the known distance to the echoing wall. The measurement will probably not be exactly 1,100 feet per second, but with many pupils it may be close enough to suggest that the figure of 1,100 feet per second is reasonably accurate.

By a demonstration on the school playground you can show that sound travels more slowly than light. Station a pupil at the opposite end of the area. The class can observe the downward stroke of the pupil's arm as he hits a large drum. How soon do they hear the sound? A stop watch is again needed. Ask the class to suggest a means of measuring the speed of sound. Can they measure the speed of light (sight)?

Experimenting with Sound Mufflers. Pupils can accumulate various materials such as corrugated cardboard, acoustic board, plywood, newspaper sheets, etc. Place an alarm clock in a box lined with one of the materials. Repeat with each of the others. The class can determine the best sound muffler.

Bring in an old automobile muffler and allow the class to explain its action in cutting down sound.

Demonstrating Pitch. To show that the faster an object vibrates, the higher is the pitch (frequency of vibrations), lay a ruler extending three inches beyond the edge of a table and clamp or hold it down tightly. Pluck the ruler's end and note the sound.

Repeat the procedure after extending the ruler six inches; then, ten inches. When did the ruler appear to vibrate most (go back and forth most rapidly)?

Ask pupils to suggest how they may demonstrate that a short air column vibrates more rapidly than a long one. Fill a pop bottle until it is seven-eighths full. Blow across the mouth of the bottle. Remove water until the bottle is half full; remove water until it is only one-eighth full. Which column of air produced the highest note? (The bottle seven-eighths full.)

Bring out that the pitch of one's voice depends on how rapidly the vocal cords vibrate. Ask pupils to place their fingers against the voicebox (Adam's apple) and feel the vibrations. The vocal cords of men are longer than the vocal cords of children and women. Compare this with the 12" ruler which extended ten inches over the edge of the table. Bring out that both the ruler and the vocal cords of men vibrate more slowly, resulting in a lower pitch.

Demonstrating the Difference Between Pitch and Amplitude (Loudness). Use diagrams of sound waves based on Fig. 294 on text page 542, or obtain an oscilloscope from a physics laboratory. Have members of the band (or pupils in your class) play the same note on such instruments as the violin, oboe, or horn, etc. Note the height of the wave on the oscilloscope screen when a louder note is heard (at the same pitch).

Demonstrating Resonance in Different Things. A pupil can strike a tuning fork and allow the class to listen to the sound. Now strike the fork and place the end against a door or box. This build-up of sound as one sound wave reinforces another is called resonance. Vibrate a tuning fork over a tall glass cylinder. While keeping the fork vibrating, gradually add water to the cylinder. A point will be reached where the sound will increase to maximum loudness, and then decrease as more water is added. At the point of maximum loudness the vibration of the air column is just the correct rate to cause resonance with the tuning fork.

Why do male and female frogs differ in their sounds? (If frogs, such as the grass frog, *Rana pipiens*, are available, hold the male frog gently under the forearms. Notice the resonating (vocal) sacs fill with air. Compare with the female frog.)

HELPING THE SLOW LEARNER

Have the slow learner fill eight glass tumblers with water at varying heights (from low to almost completely filled). He can try to adjust the columns of water in the tumblers (or test tubes) so he can play an approximate scale of musical notes. Use a pencil for striking the glass side. Encourage him to try pieces of

metal of ascending sizes suspended by strings. He can note the difference in pitch.

To demonstrate that sound can travel through a solid substance, he can make a string telephone by punching a hole in the bottom of a tin can or a cardboard cup, run a string through the hole and knot the end. Do the same for the other end of the string and a second container. Have him determine the maximum length of string which can be used for effective communication.

HELPING THE RAPID LEARNER

The rapid learner can study sound waves further by changing the vibration rate of a second tuning fork and getting interference of sound waves with the first tuning fork. Two tuning forks of the same frequency, each mounted on a resonance box, are struck individually so they will vibrate at the same time. Listen for a steady, loud sound that gradually dies down.

Tightly wrap a rubber band around one prong of *one* of the tuning forks. Set each fork vibrating again. Is there a noticeable difference in the steadiness of the sound? Is there a rise and fall in the loudness? Try moving the rubber band to different positions on the fork or add another rubber band to the second prong. The added weight changes the vibration rate of this fork. Very marked interference can be attained when the vibration rate of one fork is changed slightly. (Let students count the beats.)

If the rapid learner is interested in music (plays a piano, for example), suggest he set up test tubes containing different amounts of water and try to tune them to the musical scale of a piano.

Is he interested in a research project to determine what sound frequency range each pupil in the class can determine? Many hi-fi record shops have a record of sounds with their frequency numbered. In general, we cannot hear low-pitched sounds whose waves hit our ear at less than about sixteen times a second. Sounds which strike our ear faster than about 16,000 times a second are hard to detect. Some stores will gladly lend you the record.

Allow the rapid learner to set up a testing procedure and collect data for each pupil on minimum and maximum frequencies heard. Perhaps he will want to construct a large chart listing the pupils by code number or letter. He can decide whether to repeat the test a month later.

Or he can make a report on ultrasonics in medicine, on studies with bats and sound navigation, or on ways aeronautical engineers are trying to meet the problem of excess noise.

CHAPTER 27: LIGHT AND SIGHT
(text pages 547-60)

• CONCEPTS AND KEY ACTIVITIES

1. *There are many sources of light energy; light waves travel at high speed in a straight line.*

2. *White light can be broken up into a spectrum.*

One approach is to have the class consider the need for light. Can we exist without light? The sun's light energy warms the earth and keeps us from freezing. The food we eat, the fuel we use, the clothing we wear, etc., can be traced to the sun's light energy.

Pupils can give examples of the use of light energy for vision; also in photography when light causes the chemical changes on the film. They may recall from an earlier unit that winds arise from unequal heating of the earth's surface.

What energy changes can produce light? You may wish to develop further Table 15 on text page 550, illustrating some of the energy changes which produce light. Some teachers allow slower children to demonstrate the simpler activities and suggest additional examples of radiant energy production.

Demonstrating a Spectrum of White Light. It may be possible to obtain periscope prisms inexpensively from a war surplus store. Consult also advertisements in *Science News Letter* and *Sky and Telescope*. Divide the class into small groups, after discussing rainbows or showing the effect of a beam of light shining through the water in an aquarium tank.

Arrange a window shade so that a narrow beam of sunlight falls on a triangular prism. Place a sheet of white paper in the path of the beam coming through the prism and note the sequence of colors. Are they always the same colors and in the same sequence? Pupils can reproduce the spectrum with colored crayons. Look up the wave lengths of each color of the white light spectrum. Include these figures in a large chart of the spectrum. Some students can anticipate Chapter 29 by looking into the wave lengths of light beyond the visible spectrum (infrared; ultraviolet). Lead into a discussion of light frequencies and wave lengths and the speed of light.

Demonstrating the Motion of Light Waves. Pass a rope through the vertical slats of a wooden chair and have two pupils each hold one end of the rope. One pupil can send vertical waves along the rope. Now shift the chair so that the slats are horizontal. Send horizontal waves along the rope. What will happen when light waves, which can move in both horizontal and vertical waves, have their

horizontal wave blocked? Use the rope analogy and pass the rope through two chair backs, one with the slats vertical and the other with the slats horizontal. Show the vertical rope wave passing through the vertical slats (the first chair back) but being blocked by the horizontal slats. Discuss the nature of light and lead into polarizers, if there is interest.

Demonstrating Polarized Light. Have a pupil demonstrate a Polaroid filter. Ask the class to account for the darkening effect. (When the beam of light passes through a Polaroid filter, the only waves that get through are those vibrating in the direction of the slits formed by tiny crystals in the filter. This light is said to be "polarized.") Can a Polaroid filter be used to cut down glare? Rotate it slowly and note the effect. Now try rotating a second Polaroid filter at right angles to the first one. Ask pupils to explain the darkening and compare it with the previously demonstrated rope analogy.

Films and Filmstrips. Light Control Through Polarization is a free film which explains the principle and uses of polarization. *Light* is a filmstrip in color which describes the nature of light rays and characteristics of objects which reflect or transmit them. *Light Waves and Their Uses* discusses interference, spectra, and polar screens.

For the Bulletin Board. Post various colored photographs of familiar objects such as green grass and red apples. Under each photograph ask questions as to why the grass is green (it reflects mainly the green light of the spectrum falling upon it) and the apple red (reflects mainly red light).

HELPING THE SLOW LEARNER

The slow learner may have his interest aroused by making blueprints of leaves, keys, plastic rulers, etc. Obtain blueprint paper from a scientific supply house or a store that sells drafting supplies. Some blueprint stores will save the ends of a large roll of paper and give them to teachers without charge. Use various light sources, including the sun, a 250-watt bulb, and a 100-watt bulb. Can the student suggest a procedure for determining the best exposure time for each light source? Which light sources are most impractical?

The slow learner will find the booklet *Light*, by Bertha Parker, easy to follow, especially the section on the various uses of light.

3. *Understanding the structure of the eye enables us to appreciate the need for its care.*

Ask whether any pupils have had trouble with their eyes. On the board, list eye difficulties under such categories as "accidents,"

"infections," "impaired visibility." What parts of the eye were affected? From this, go into the concept of structure, function, and care of the eyes.

Dissecting the Eye of a Cow. After a preliminary study of eye structure, a pupil may dissect a cow's eye and prepare a large chart or colored chalk drawing to show each part revealed by the dissection. Encourage questions. If the dissector (or another pupil) cannot answer the questions, suggest library research.

Readings. Many life insurance companies have booklets on the eye and its care which they will send you. The Better Vision Institute (630 Fifth Avenue, New York 20, New York,) has literature for distribution.

Field Trip. A committee may wish to interview briefly any or all of the following persons interested in the care of the eye: an oculist (or ophthalmologist) who is a medical doctor; an optometrist (one who examines eyes in order to prescribe glasses if needed); an optician (one who makes or deals in lenses). Have the class suggest questions in advance of the interviews. Are there many eye injuries among people in the community? Of which specialist would you ask this question? If you have a prescription for glasses, which specialist would you visit?

Films and Filmstrips. *Eyes and Their Care* and *How the Eye Functions* may be shown as an approach to the study of the eye, to illustrate a library research report, or as a summary.

The color filmstrip *Your Eyes at Work* can be shown with a committee report, provided the chairman first previews it and then prepares some key questions.

Demonstrating Charts and Models of Normal, Nearsighted, and Farsighted Eyes. Ask if the pupils know whether they are nearsighted or farsighted. What kind of lenses correct each condition? Use the diagrams on text page 555 for discussion. Students can prepare charts in their notebooks, noting the shape of the eyeball for each condition.

Try to borrow from the high school a commercial model of an eye. Perhaps a pupil can construct a model, using a plastic sphere, paint, and modeling clay.

A Survey of Lighting Facilities. Suggest that pupils make an outline sketch of the rooms in their home and indicate the wattage of the lamps used in each room. Where in each room are the lights located? Why do authorities recommend normal lighting in a television room, provided there is no reflection from the screen? Use the rules for good lighting (see text page 553) as a guide for the survey. What are lighting facilities in the school room?

HELPING THE SLOW LEARNER

Children at this grade level are undergoing such rapid body changes that a careful eye examination should be given during the year. Possibly the child with reading difficulties may need glasses or a thorough medical examination.

If the school does not give eye tests, try to borrow an eye chart (such as the Snellen Eye Chart) with letters of different sizes. Why not have one of your science-shy pupils help you administer this test?

HELPING THE RAPID LEARNER

Have the rapid learner read Newton's account of his work with dispersion of light (pages 393-400 of *Moments of Discovery: The Origins of Science*).

If there is a military base near your school, suggest the science-prone child write the Information Service Officer and ask if there is a Night Vision Training Unit. He may be able to secure an interview with the aviation physiologist in charge. Then he can write a report on the use of our eyes under very low illumination (night vision). What military advantages are there in this knowledge? The Office of the Air Surgeon (Information Section) may be willing to send information on vision to a pupil who shows high interest and ability in this field.

Or the rapid learner may want to do further reading in *The Physical World* (pages 310-16) on the measurement of light and types of lighting.

Or he can experiment with lenses and determine the focal length of each (see the section under "Going Further" on text page 559).

CHAPTER 28: SENDING AND STORING SIGNALS
(text pages 561-79)

• CONCEPTS AND KEY ACTIVITIES

1. *The telegraph and the telephone make use of electricity and electromagnets in sending word signals along wires.*

Ask pupils to suggest devices which use wires to transmit messages. List the responses on the board (telegraph, telephone, teletype machine, and the bell, buzzer, and gong in a school). Develop the idea that some of these machines are similar in construction. Show models of a telegraph sender and receiver

(purchase from a scientific supply company). Examine a bell, buzzer, and gong. When is the circuit completed? When is it broken?

Demonstrating the Operation of a Telegraph. A committee can make the two-way telegraph illustrated and described on text page 563. Remember to coil the wire in opposite directions on the two nails, which can be used in making the electromagnets; you will thus get the proper north and south poles. Ask how the electromagnet can be increased in strength (add more turns of wire; more dry cells in series).

Demonstrating the Morse Code. Some pupils (Boy Scouts, etc.) may be familiar with the Morse (or the International) code. Have one student send a message on a model sender to another student outside the room. Elicit an explanation of how the circuit is made and broken.

Field Trip. Visit a railway station to examine a telegraph in operation. If you live in a large city, try to visit an office such as Western Union. Some companies use high-speed automatic machines.

An improved telegraph unit is the teletype machine which you may see in newspaper offices, large railroad stations, and weather stations.

Films and Filmstrips. You may approach the topic with the film or filmstrip *Electromagnets*. Then lead into discussion of the telegraph set, after dealing with some of the topics in the film and setting up some of the simple equipment and demonstrations shown.

A good way to lead into the discussion of the telephone is to have pupils set up a working two-way toy telephone system, stringing the wires around the classroom. Use the Harbrace filmstrip *Calling Your Neighbor* to develop principles shown by the telephone. Students can read the filmstrip captions slowly. Then, a stop can be made at each frame for questions and discussion. For example, a vibration of a diaphragm can be shown by having a pupil hold a piece of stretched tissue paper in front of his lips (without touching) as he talks. Another pupil can feel these vibrations with his fingertips.

An Exhibit of Old Telephone Equipment. Inquire if your telephone company has an exhibit of early telephones to lend. Students can build a giant model of a telephone transmitter to accompany this exhibit. Use cut-up, disk-shaped sections of a dry cell carbon rod for the carbon of the transmitter. Place the carbon disk in a strong cardboard tube, closed at one end with a copper foil plug. The other end should be covered with a flexible diaphragm of thin sheet metal. Connect the apparatus to a meter and a battery. Note that as the diaphragm is pushed harder, the current flows.

Demonstrating the Parts of a Telephone. The telephone company may lend or possibly donate several obsolete telephones. Examine the diaphragm, and other parts in the transmitter and receiver sections. Where are sound waves changed into electricity? How is electricity changed back to sound waves? Pupils can look for the electromagnet and the diaphragm in the receiver (as the diaphragm in the receiver vibrates, it sets up vibrations in the air similar to the speaker's voice).

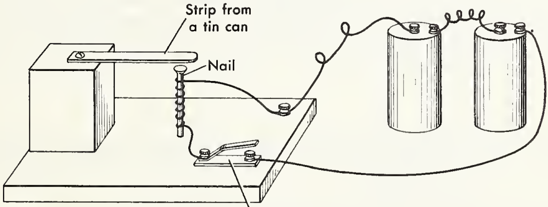
Arranging for a Guest Speaker. In some areas, the phone company will provide lecturers and demonstrators of telephone equipment. Encourage questions on any point not made clear.

HELPING THE SLOW LEARNER

Some simple experiences will help the science-shy pupil understand how an electromagnet in a telephone or telegraph works. Assemble a 24" length of insulated copper wire (such as plastic-coated bell wire) and a 4" iron spike. Coil the wire around the iron nail about 12 times and connect the scraped ends of the wires to the terminals of a $1\frac{1}{2}$-volt dry cell. How many tacks or paper clips can the pupil pick up with the device? Can he devise an experiment to show that the strength of his electromagnet depends on the number of turns of wire or the amount of current flow? The strength can be determined by the number of tacks or clips picked up.

Suggest that the slow learner draw up a table in two columns, showing in column A the number of turns of wire, and in column B the number of tacks picked up. Perhaps he can construct a simple graph of the data he gathers.

A simplified telegraph set can be made as shown in the diagram below.

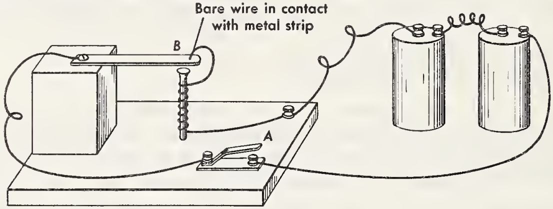


This telegraph model suggests a school gong in action. The pupil can study a buzzer or a bell and note the provision for intermittent strokes of the armature. A diagram on the board, similar

to the one below, will furnish a clearer picture of how the buzzer vibrates. Can he convert his model to this buzzer model?

Trace the flow of current when the key (a strip of metal from a tin can) at *A* is held down. Can he explain what causes a temporary break in the circuit? (The electromagnet pulls the armature down and the circuit is broken; the metal strip then springs back to make contact with the bare wire at *B*, causing the nail to become magnetized again, etc.)

Encourage the pupil to demonstrate the action of his models before the class.



HELPING THE RAPID LEARNER

The rapid learner can report on the operation of a telephone dial system. His research can include a visit to the local telephone company for literature and loan of possible equipment. Try to obtain *Dialing the Nation*, a free loan film about long distance dialing, or *Highways for the Telephone*, an animated film of a microwave relay network. The science-prone child (and others in his group) may use these films in a science club presentation or in class. *The Physical World* (pages 352-54) has a diagram and description of a telephone dial system.

Have the rapid learner investigate the use of teletype systems in distributing weather information. Visit a weather station and watch the operation of the machines. The operators will be glad to give you discarded portions of teletype recordings for the bulletin board.

2. *Sound recordings and photography help man better to understand his surroundings.*

How does man make use of sound recordings in his daily activities? Have pupils list main categories such as industry, medicine, agriculture, schools, etc., and suggest the uses and advantages of such recordings. Most schools today have record players and tape recorders which can be used for demonstration, or some pupils may bring their own portable models from home.

The same approach can be used to introduce the subject of photography. A student can also work up a report on the use of photography in the armed forces.

Students can bring their cameras (or pictures of cameras) to class. After several have explained the different kinds of cameras, lead into a discussion of the basic parts and how they work. The section at the end of this chapter, "Photography as a Hobby" (text pages 580-85), may suggest other approaches.

Demonstrating a Variable-Speed Record Player. Perhaps a pupil can bring in a portable record player with variable speeds of 16, 33, 45, and 78 rpm. Discuss the advantages of records designed for each speed. Have a pupil report on high-fidelity (hi-fi) sound reproduction. What are its advantages? He can include a report on stereophonic sound and its advantages, too; another pupil may report on this topic.

Demonstrating a Tape Recorder. If the school has a tape recorder, or if a pupil can bring one in, make a recording of class conversation and have a knowledgeable pupil explain how it works. What is a magnetic tape? (Iron oxide on a plastic tape is modified by an electric current to form a magnetic pattern.)

Demonstrating Photographic Processes. Pupils familiar with simple developing techniques can help demonstrate the making of contact prints. "Subjects" can be leaf specimens, India ink outlines on cellophane, or old negatives brought from home. *Science Teaching Ideas II* (1955), pages 28-31, describes the use of Kodak Velite paper and Tri-Chem packets of developer, stop-bath, and fixer, all weighed for making solutions in eight ounces of water. Developing can be performed with classroom shades drawn (some of the ceiling lights can be kept on).

A glass printing frame can be made with a 5" × 7" glass plate taped to a 5" × 7" sheet of corrugated cardboard. Place masking or adhesive tape around the edges of the glass. A 150-watt electric bulb can serve as a light source. It is a good idea for pupils to pencil their names on the back of the Velite paper. Place a negative (excellent directions are given in packages of Tri-Chem) against the shiny (emulsion) side of the Velite paper. The understanding of under- and overexposure, under- and overdevelopment will become more meaningful as pupils make mistakes and try to correct their errors. Work in groups, each having pupils familiar with the techniques. The next day discuss negatives and positives, exposure time and developing time, and other topics.

Demonstrating Persistence of Vision. Pupils can perform the activities described on text page 574 which show how to make a flip-book. Then lead into a discussion of motion pictures.

Demonstrating the Use of Film and Slide Projectors. If there is a student film squad, have one member describe the use of the film projector and another the use of the slide projector. Slow the

machine down, if the projector has a rheostat. Then speed up the machine. For normal projection of 16-millimeter silent film, how many frames are projected a second? (16); for 16-millimeter sound film? (24)

Explain that in the projection of a slide or film, a mirror behind the lamp and lenses in front focus a bright beam on the slide or film. The front, or objective, lenses focus an image on a screen.

For the Bulletin Board. Arrange an exhibit of photographic prints representing all grades of good and poor pictures. A committee can compose suitable questions to lead the class to analyze the merits (or lack of merit) of each picture.

Demonstrating the Working of a Sound Projector. Show the sound track on the film and demonstrate the principle of the photoelectric eye. Place an index card in the path of the beam and note that the sound is cut off. Elicit an explanation of how the sound track is converted to sound.

Films. Behind Your Snapshot tells the story of the manufacture of camera film.

Sound Recording and Reproduction is an old film but the basic principles depicted can be discussed.

HELPING THE SLOW LEARNER

Have you ever used the school tape recorder (if one is available) to record a science radio program? The two key points in the making of this recording are proper maintenance of volume and use of the microphone. A science-shy child may be stimulated in his desire to learn by being permitted to operate the tape recorder. He (and others) can discern the presence of the iron oxide particles by covering a short piece of the tape with a layer of waxed paper and drawing a magnetized needle cross-wise along the tape at intervals of one inch. Did the magnetic needle interfere with the sound playback? (The class will hear clicking noises where the iron particles on the tape were magnetically rearranged.)

Simple blueprinting or use of slow-reacting Velite contact paper will stimulate the interest of the slow learner in photography. Refer above and to the text for additional directions.

If the slow learner has a box camera with a fixed focus, suggest he open up the back and tape onionskin or waxed paper over it. Keep the shutter open by setting it for a time exposure and note the position of the image on the paper. A dark cloth cover over the back of the camera and the pupils' head will aid him in making observations.

Perhaps his camera has an adjustable focus. Try focusing on nearby and on distant objects. Notice in which direction the lens is moved to focus a clear image on the paper screen.

HELPING THE RAPID LEARNER

Suggest that the rapid learner write to the Eastman Kodak Company, Rochester, New York, for free pamphlets on photography. Arrange a class exhibit of these materials. Later, the science-prone child interested in photography can organize a committee of pupils of average and below-average academic abilities who share a common interest—photography. A class or school exhibit of photographs can be displayed. Why not organize a photography "clinic" and invite a local photography hobbyist or storekeeper to give suggestions?

The rapid learner can explore further the topic of making talking pictures. He will find that sound can be recorded in several ways (see the chart and text in *The World Book Encyclopedia* for graphic representation of how the film pattern is changed into sound).

Allow the rapid learner to study the operation of a 16-millimeter sound projector. Many machines contain a built-in diagram. Or he can refer to page 218 of *Audio Visual Methods in Teaching*, an excellent reference for the science teacher looking for new ways to present illustrative materials. Or write to the manufacturer of the machine for additional literature.

If a photoelectric cell is available, the science-prone pupil may be able to devise a method of counting pupils as they enter a classroom, or invent other uses for it. How is the photoelectric cell used in industry? Have him report on this topic.

PHOTOGRAPHY AS A HOBBY (text pages 580-85)

Photography is a fascinating hobby for many school students and need not be expensive. The introduction to principles of photography in Chapter 28 can be extended by using this section at this time. Allow pupils familiar with photography to organize a panel discussion on their hobby. A parent (or the local photography retailer) may be glad to give a talk illustrated with simple materials.

First, demonstrate the general use of a camera in taking good pictures. Other pupils can then present the special features of their own cameras. Next, discuss developing the film, making prints, making enlargements. Manual pages 189 and 190 suggest procedures which may be followed in a partially darkened classroom. Encourage experienced pupils to demonstrate these processes with their own equipment. Supplement with a film on

taking, developing, and enlarging pictures. Free booklets and a loan film may be obtained from the Eastman Kodak Company, Rochester, New York, or from the Ansco Corporation, Binghamton, New York. You may want to show this film as part of an auditorium science program. A photography club will afford many rewarding hours for your interested pupils.

At several points in this Manual, we have suggested the feasibility of a specific science club, in addition to a general science club. If you have the opportunity, the endurance, and the time to organize a club, you will find a great amount of help in the *Science Sponsor's Handbook*, available for a nominal fee from Science Service, 1719 N Street, N.W., Washington, D.C.

Other materials may be obtained from Future Scientists of America, National Science Teachers Association, 1201 16th St., N.W., Washington, D.C.

CHAPTER 29: ELECTRONIC MESSENGERS
(text pages 586-605)

• CONCEPTS AND KEY ACTIVITIES

1. *Man has been able to make use of many kinds of electromagnetic waves.*

2. *The effects of visible light can be seen by man; other types of electromagnetic waves are revealed by man-made detectors.*

One approach is to refer to a barrier to man's conquest of outer space—cosmic radiations. By questioning, elicit that information about cosmic radiation is constantly being obtained by artificial satellites. Bring out that these very penetrating waves are a kind of electromagnetic wave. Refer to the chart of the complete electromagnetic spectrum obtainable for a slight fee from the Westinghouse Corporation (or have a pupil reproduce on cardboard or the chalkboard a large vertical chart of the spectrum on text page 590).

Another way to start is to refer to Fig. 322 and have pupils suggest the effects or uses of the various waves indicated. For instance, bring out that cosmic, gamma, and X radiations are very penetrating. On what basis is the spectrum broken up into divisions? (According to wave length.) From this point go on to a discussion of wave lengths and frequencies. Use the chart for such pupil observations as that short waves have the highest frequencies; the more penetrating waves are found on the top of the spectrum

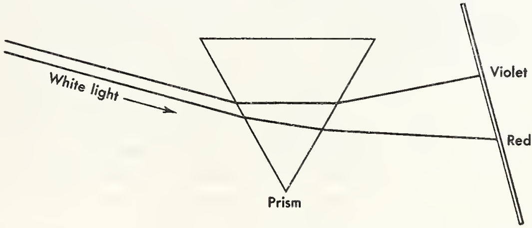
band (short wave end of the band). A chart arranged horizontally will show these waves at the right side.

Refer to text pages 588-89 and give the pupils an opportunity to calculate the frequency of a wave, if the wave length (L) and speed of light (v) are known:

$$f = \frac{v}{L}$$

Practice in the powers-of-ten notation can be given at this time. You may want to refer the class or especially interested students to the section "If You Are Interested" at the end of the chapter.

Demonstrating a Spectroscope. First, review the use of a prism to break up white light into its component colors. Place a diagram on the board based on the results obtained from a beam of light (from a 2" × 2" projector, for example) passing through a prism:



Refer to a chart of a white light spectrum and have pupils determine which color has the longer wave length (red waves are about 1/30,000 inch long; violet ones are 1/65,000 inch long). Ask pupils to comment on the violet and red beams. Which swerves more sharply? (Violet; it travels more slowly through the glass medium.) Shorter wave lengths travel more slowly through a transparent medium like glass.

If you can borrow a spectroscope (an instrument used to examine spectra and determine their composition), set it up so that pupils can see a white light spectrum (a continuous visible one). Perhaps a science-prone pupil will want to read about absorption spectra (black absorption lines in the continuous spectrum which identify the wave length of rays of light given off by an incandescent element). The rapid learner may obtain the individual spectrum colors of an element by moistening the salt of the element with dilute hydrochloric acid, picking up a small amount on a platinum wire, and heating it in a gas flame. Examine the flame with a spectroscope and match the location of the various colored lines with those on a chart of the spectra of different elements. Note the black absorption lines for a specific element. A darkened room will give better results.

For the Bulletin Board. Collect X-ray photographs (or illustrations from magazines) of bones, teeth, metal castings, and

patients undergoing radiation therapy. Why do these bones show up but not the softer tissues? (The X-rays do not penetrate the harder bone tissue as readily; hence they do not affect the photographic film as much.) An effective way of displaying X-ray photographs is to make a cut-out plywood panel and place a light source behind the photographs. Or tape the pictures to the classroom windows.

Post photographs taken with infrared light and printed. Compare with a similar scene taken with ordinary film.

A Report on Ultraviolet Ray Effects. Why is it dangerous to look at the arc produced by a welder's torch? (The retina may be damaged.) A committee can look up information on uses of ultraviolet and set up a demonstration of "black light" on different minerals. Have a student point out on a light spectrum the location of the ultraviolet region ("black light"). A report should include uses of ultraviolet light for irradiating milk, sterilizing food and sanitary facilities, and fluorescent effects.

Films. *The Strange Case of the Cosmic Ray*, a free color film available from the Bell Telephone Company, discusses the source, nature, and effects of cosmic radiation. You may want to use the film as an approach to the concept of electromagnetic waves.

Curves of Color portrays the discovery of the visible spectrum and the complete electromagnetic spectrum. Use the film either as an approach or to summarize the concept.

HELPING THE SLOW LEARNER

A supervised study lesson may help the slow learner grasp some of the basic ideas in the text. He may find the nonmathematical portions easier to comprehend. For example, text pages 591-94, on ultraviolet rays, can be read silently or aloud by individual students, and discussed paragraph by paragraph. Have some of these pupils write one-sentence summaries of significant paragraphs. Encourage the slow student to cite examples of ultraviolet use which may have affected him personally. Why is it dangerous to look at the sun with the naked eye? (Retinal burns are produced which may result in additional blind spots and other cell damage.)

Use various color chalks to illustrate what is meant by wave length. Encourage the pupils to locate waves of different wave lengths on the chart.

Portions of the free booklet, *The Story of X-rays*, can be read in class. Have the science-shy child make blueprints of X-ray negatives. Or he may make contact prints with Velite paper and develop with the Tri-Chem packet (see Manual page 189 for directions).

HELPING THE RAPID LEARNER

The lives of famous scientists associated with discoveries mentioned in this chapter bring a personal touch and some inspiration to pupils who show high-level ability in science. For instance, the story of Hertz's experimental production of electromagnetic waves by means of an oscillating electric current is told in his own words on pages 901-12 of *Moments of Discovery*: Vol. 2, *The Development of Modern Science*. In the same volume, articles by Roentgen (discovery of X-rays), Becquerel (experiments leading to the discovery of radioactivity), Pierre and Marie Curie (the discovery of polonium and radium), and others are included.

The last article in this interesting volume includes J. Robert Oppenheimer's address to winners of the Westinghouse Talent Search scholarships (delivered five years before he retired from the Atomic Energy Commission). Your science-prone pupil will receive some degree of inspiration from the remarks Oppenheimer directs to the assembled students who represent a high degree of science talent.

Suggest that the rapid learner try some of the activities described under "Going Further" on text page 604.

CHAPTER 30: SENDING SOUND AND IMAGES THROUGH THE AIR

(text pages 606-24)

• CONCEPTS AND KEY ACTIVITIES

1. *Radio and television have enabled us to transmit both sound and pictures for better communication.*

One way to start is with a field trip to a local broadcasting station. The class can observe the studio, note the location of the microphones, and try to determine the use of the amplifiers in the engineer's room. They should note, too, the transmitter and the antenna if it is nearby.

The class (or a committee) can visit the local police radio transmitting station. Or a radio "ham" may be able to show his two-way radio transmitter and receiver.

Encourage a list of questions for further exploration, after one of these visits. What about terms mentioned by the radio

operator? (e.g., kilocycles, vacuum tube, condenser, amplifier, tuner, etc.)

Demonstrating Transmission of Signals Without Wires. Another approach to the concept can be the sending of an impulse through the air (for a short distance of several inches). This activity will be based on the fact that an alternating current in one coil of wire sets up an alternating current in another coil a short distance away.

Remove the iron core from a transformer and connect the wires of the secondary coil to a socket holding a small lamp. It will be noted that alternating current flowing through the primary coil sends out moving lines of force (similar to a radio station). As the moving lines of force cut across the secondary coil a few inches away, they induce a current in it which will light a small lamp. Point out that radio waves induce current in your radio receiver in a somewhat similar way. From this simple demonstration go into a discussion of frequency (rate at which the lines of force change) and kilocycles, keeping in mind the idea of radio waves as waves of alternating lines of force. Draw the comparison that the broadcast antenna and the receiving antenna are similar to the primary and secondary of a very large, inefficient transformer. In the receiving antenna, tiny alternating currents are induced by radio waves.

Building a Radio Set. A group of interested pupils can build a small radio as a long-term project in advance of or concurrently with the class study of the topic. A crystal set or a simple vacuum-tube receiver is recommended. Some dealers have a kit of materials. Consult *All About Radio and Television* as well as *The Boys' Second Book of Radio and Electronics* for details. Use the pupil projects to motivate discussion.

Demonstrating the Principle of the Vacuum Tube. Demonstrate the parts of a radio tube such as the triode. You will need several tubes and a chart or a color diagram on the board. Show the hot filament, plate, and grid. Point out that the charge on the grid controls the flow of electrons. For example, negative voltage on the grid repels negatively charged electrons boiling off the filament, and decreases the number that can flow through the tube.

Ask a pupil to help you demonstrate that electrons can be removed from atoms by heating. Make a thermocouple by fastening together the ends of a copper and an iron wire. Attach the free ends to a galvanometer. Heat the fastened ends in a gas flame. What effect does this heating have? Have pupils venture explanations of how heat affects the atoms in the thermocouple. Where does the current come from?

For the Bulletin Board. Post photographs and articles which show uses of radio (e.g., radio-equipped police cars, aircraft, taxis, walkie-talkies, artificial satellites, etc.) List under long waves, short waves, ultrashort waves, and microwaves.

Make large diagrams on cardboard, in colors, to show how your radio works from the time a signal takes a ride on a carrier wave to the time it hits your ear in your living room as a sound wave.

Films and Filmstrips. If you wish to illustrate further the importance of the vacuum tube, a free film, *Bottle of Magic*, shows the historical development of the tube and many applications. Or you may want to discuss the functions of vacuum tubes after showing the film *Vacuum Tubes*, which discusses amplifiers, oscillators, and detectors. You may find it convenient to introduce the concept with these films.

The Harbrace filmstrip *Calling Your Neighbor* can be used as a review of radio principles or as an introduction to television. *The Story of Television* shows the development of TV and tells how the equipment works. See the complete list of films on Manual page 176 for additional titles, many available as free loans.

While viewing the filmstrip *Calling Your Neighbor*, for example, it will be noted that some of the frames refer to the electron beam that scans the image (this divides the picture into many small lines). This may be a good time to demonstrate the photoelectric effect.

Demonstrating the Photoelectric Effect. Move a photographic exposure meter toward or away from a source of light. Have several pupils take readings of the meter and record the results on the board.

Or you may direct a source of ultraviolet light upon a well-polished zinc plate attached to the knob of a positively charged electroscope. What happens? (The electroscope is discharged.) If the electroscope is negatively charged, there is no effect. The ultraviolet light releases electrons from the zinc.

Field Trip. For a visit to a television studio, refer to activity 3 on text page 622. Some industrial concerns use closed-circuit television to communicate with their employees. If you can arrange a visit to such an industrial plant, the class may be able to witness an important means of communication. Where else is closed-circuit television effective? (Surgical operations, at conventions, in some schools, etc.)

A substitute field trip is the film *Sightseeing at Home*, which takes you to a studio to see a program televised. *Magic in the Air* uses animated diagrams to show the principles of TV.

HELPING THE SLOW LEARNER

Portions of *Television Works Like This* have a relatively simple text and many simple illustrations that will help the slow reader.

He may be able to conduct a class survey (or interview a local TV repair man) to determine causes of TV set difficulties.

Tabulate the number of people interviewed, troubles (picture tube, other tubes, antenna, location of set, etc.), and elicit pupils' opinions on their choice of TV programs, etc.

2. *Radar has helped man better to adjust to his surroundings.*

A committee report on the various uses of radar and how it works can lead off discussion. Ask pupils to recall experiences with radar equipment. This may stem from scenes observed in films or television programs, or be a result of field trips to airfields, the radarscope on a ferryboat or ship, or the uses of radar in traffic control, etc.

Films and Filmstrips. *Safe Passage*, a free film, may be used to explain basic principles of radar and its application to ships. *Sentinel in the Sky* presents the five main components of radar equipment. A committee may be able to use it to supplement its report.

A Class Skit. The opportunities for dramatizations which radar presents can be made the basis of a class play. A committee can write a script based on actual happenings. Ground-control-approach radar (GCA) has brought many planes in safely in bad weather. The main part of the skit can deal with the safe landing of a plane which is "talked in" by one of the students.

Arrange for a committee to visit a local airfield which has GCA equipment, to gather data and background. How many times has the apparatus been used during the past year? Perhaps the data can be given to the committee and a graph constructed and presented after the skit. Pupil planning for the skit will result in need for additional library research. Pupils can build a simulated radar screen, revolving antenna, and other stage properties.

For the Bulletin Board. A committee can prepare a series of photographs showing uses of radar. Paste each picture on white cardboard and use black crayon or ink to show radar waves bouncing back. For example, a plane can be shown hidden by clouds but revealed by radar waves bouncing back to the sending aerial. A weather balloon can be followed through an overcast.

HELPING THE SLOW LEARNER

A simple speaking part (or work on a "stage" crew) in the skit mentioned above will help give the science-shy child status in his class. Such participation will also help stimulate his interest in the topic.

Ask him whether an airplane passing over his home can possibly affect the reception of his television set. Develop the idea of echoes of short waves from the transmitter of the television

station hitting the metallic hull of the airplane and being reflected and arriving late at the antenna.

At this point you might try a supervised study lesson. Text pages 617-21 contain relatively easy descriptive material which the slow learner can digest. Encourage him to summarize in one sentence the main idea of a paragraph. Have him give one example of the use of radar. Then, refer to the following paragraphs which cite additional examples.

HELPING THE RAPID LEARNER

The rapid learner can report on radio astronomy. Have him include the tracking of artificial satellites in his report. He could also report on the use of radar in civilian transportation and military operations.

He can draw a large diagram (in colors) of what happens from the time a picture is focused by a TV camera until the image appears on the TV picture tube. He should be prepared to explain this diagram as he gives his report. (See pages 367-69 of *The Physical World*, for additional reference.)

Radio Projects will give an introduction to the construction of basic radio circuits. *Radar and Other Electronic Inventions* will give additional background on the use of electronic devices in military, navigational, communication, and medical fields.

Why not encourage the science-prone pupil to write a story describing an imaginative future use of some electronic device such as radio or television? Can he improvise an "improved" instrument? He might tie it in with a space flight in the future.

He may be interested in demonstrating the effect of a diode (such as 6H6 dual diode). This demonstration can show the effect of heat on the emission of electrons from the cathode of a vacuum tube. See page 429 of *The Physical World* for full directions, including a diagram. A local TV repair shop may supply tubes gratis or at cost.

SUMMARY AND USE OF TESTS

Junior high school students, growing up in a world that is probing outer space, should be able to grasp the idea that speeding the communication of ideas between people and nations makes for better understanding and progress. In the long run all technological progress (such as the increased effectiveness of electronic messengers) is limited by one important factor: man's proper use of them.

The spoken and written word helps in communication. Point out that scientific journals and scientific meetings help scientists exchange ideas and understand each other better.

Your pupils can be shown that a good citizen is an informed one. A knowledge of the main scientific principles will give him the background to comprehend the great achievements of his day.

As a final summary of the term's work, you may want to have pupils list and discuss the many important scientific concepts or principles which must be considered when a trip to outer space is planned.

The *Harbrace Teaching Tests* to accompany *You and Science* are two 112-page booklets of objective-type tests, Forms A and B. Separate chapter tests and a unit test are provided for each unit.

BIBLIOGRAPHY FOR STUDENTS

1. Baer, M. E., *Sound: An Experiment Book*, Holiday, 1952.
2. Bendick, J., *Television Works Like This*, Whittlesey, 1954.
3. Brinckerhoff, R., and others, *The Physical World*, Harcourt, Brace, 1958.
4. *Edmund Optics*, a free catalogue of optical items from the Edmund Scientific Co., Barrington, N.J.
5. Eye and ear booklets, free from national life insurance companies and health agencies.
6. Free pamphlets on photography, Eastman Kodak Company, Rochester, N.Y.
7. Gould, J., *All About Radio and Television*, Random, 1953.
8. Literature (inexpensive) on vision, Better Vision Institute, 630 Fifth Avenue, New York 20, N.Y.
9. Marcus, A., *Radio Projects*, Prentice-Hall, 1956.
10. Morgan, A. P., *The Boys' Second Book of Radio and Electronics*, Scribner, 1957.
11. Parker, B. M., *Light*, Row, Peterson, 1949. Useful in a supervised study lesson.
12. Podendorf, I., *The True Book of Sounds*, Childrens Press, 1956.
13. Ross, F., Jr., *Radar and Other Electronic Inventions*, Lothrop, 1954.
14. *Science News Letter* and *Sky and Telescope*. These excellent periodicals frequently contain advertisements of optical equipment.
15. *The Story of X-rays*, General Electric, Schenectady, N.Y. A free booklet (class set).

BIBLIOGRAPHY FOR TEACHERS

1. Dale, E., *Audio-Visual Methods in Teaching*, an excellent book for the science teacher and others. Holt (Dryden), 1954.
2. "Enriching Science for Youngsters," *Science Teaching Ideas II*, pp. 28-31, Natl. Science Teachers Assoc., Washington, D.C., 1955.
3. Schwartz, G., and P. W. Bishop, *Moments of Discovery:* Vol. 1, *The Origins of Science;* Vol. 2, *The Development of Modern Science*, Basic Books, 1958.
4. *Science Sponsor's Handbook*, Science Service, 1719 N Street, N.W., Washington, D.C.
5. *World Book Encyclopedia*. Contains many science articles and diagrams in color.

On Your Own: Projects In Sky Watching (text pages 625-48)

As indicated in Unit 3, this section is for extended study as a long-term project. Groups of interested students, sometimes the entire class, may have had enough interest in astronomy, earth satellites, or space travel to form a club. During the year, you will have been able to draw upon their work at various times for special programs as a change of pace from the regular classroom activities. If the group has been working ahead on its own, now may be a good time to take a week or two to pull together all the explorations and discoveries that have been made. You may wish to encourage an exhibit of charts and instruments some of the students have built and invite other classes and the public.

However this section is used, it will serve to fix some of the methods of the scientist with which the text began. Incidentally, almost every hobby section in *You and Science* contributes to this final section if it is expanded to include satellites and space travel. Photography is referred to frequently in the section. Rocketry and model airplanes raise problems of celestial navigation. How living things can survive space flights involve an understanding of chemistry and the conditions needed to maintain life beyond the earth's atmosphere. Bright students or interested students who complete the activities in this section may be encouraged to explore related areas. This "On Your Own" section should extend the horizons of science for many of your students and lead them into fascinating hobbies or a lifetime career.

APPENDIX

FILMS AND FILMSTRIPS

This annotated list of 16-millimeter sound films and 35-millimeter filmstrips is intended to *supplement* the ones already mentioned in preceding chapters of this Manual. For your convenience, the films and filmstrips suggested previously are designated with an asterisk (*) and the chapters in which they are suggested for use are given in parentheses. *Filmstrip Guide* and *Educational Film Guide*, which may be obtained from the H. W. Wilson Company, 950 University Avenue, New York 52, New York, are handy references for recent films and filmstrips. Films on free loan are available from industry and various governmental agencies. Consult film libraries nearest you or write directly to the company or agency.

The films and filmstrips listed here are sound and black and white unless otherwise indicated. All films may be shown within a class period of 40-45 minutes. Consult the "Directory of Film Distributors," on Manual page 221, for complete names, departments, and addresses. The following abbreviations are used here.

f = film	c = color
fs = filmstrip	rls = reels
si = silent	ser = series

GENERAL TOPICS

Animal Life

Behavior in Animals and Plants (f,c), Coronet (Ch. 2).
Beach and Sea Animals (f), EBF, rev. 1959.
Birds Are Interesting (f,c), EBF, 1950.
Insects (f,c), EBF, 1953.
Life in Ponds, and Lakes, and Streams (fs,c), Jam Handy, 1948.
Pond Life (f), EBF, 1950.
**Problem-Solving in Monkeys* (f,si), Int. Film Bureau (Ch. 2).
Story of the Frog (f), Almanac, 1953. Life cycle and habits of the frog.
The Sea (f), TFC, 1932.

Astronomy and Space Travel

Depths of Space (f), Int. Screen Org., 1953. Studies of galaxies.
**Earth in Motion* (f), EBF (Ch. 7).
**Earth Satellites: Explorers of Outer Space* (f,c), EBF (Ch. 9).

Earth and the Universe Series (7 fs): *Earth in Space; Sun and Its Planets; Earth's Satellite—The Moon; Comets and Meteors; Stars and Galaxies; Constellations; Work of Astronomers and Space Travel,* Soc. for Visual Ed., 1952.
Eclipse (f), Almanac, 1950. Shows solar eclipse.
**Exploring Space* (f), Association (Ch. 7).
**Exploring the Universe* (f), Almanac (Ch. 7).
Exploring the Night Sky (f), EBF, 1956. Constellations, nebulae, and other star phenomena.
**Infinite Universe* (f), Almanac (Ch. 7).
Looking at the Stars (fs), Popular Science, 1951.
Milky Way (f), Int. Screen Org., 1953.
**The Moon* (f), Int. Screen Org. (Ch. 8).
**Neighbors in Space* (fs,c), Harbrace (Ch. 7).
**New Frontiers in Space* (f), McGraw (Ch. 9).
**Our Mr. Sun* (f,c), Bell Telephone, free loan (Ch. 7).
**Rockets: How They Work* (f,c), EBF (Ch. 9).
The Solar Family (f), EBF, 1936. An introductory study of the planets—their evolution, motions, sizes, and satellites.
The Sun (f), Int. Screen Org. Sunspots and total eclipse.

Atomic Energy, Chemistry

**A for Atom* (f,c), General Electric, free loan (Ch. 14).
The Atom Goes to Sea (f), General Electric, free loan. Experimental research and development of atomic-powered submarine.
**Atoms As You Will Use Them* (fs,c) Harbrace (Ch. 15).
Atom and the Weather (f), Handel, 1955. How radioactivity from atomic tests is used as a research tool by the meteorologist.
Atom at Work (fs,c), Soc. for Visual Ed., 1950. Points out peacetime uses of nuclear energy.
**Atomic Energy* (f), AEC, free loan (Ch. 15).
Atomic Biology for Medicine (f), Handel, 1955. Explains various research experiments.
Bikini Radiological Laboratory (f,c), AEC, 1951, free loan. Survey of the effects of radioactivity on plant and marine life.
Dawn's Early Light (f,c), Westinghouse, 1955, free loan. A working model of an atomic reactor, and the use of the atom in generating electricity.
Introduction to Chemistry (f), Coronet, 1949. Chemical terms, materials, and major industrial applications.
Magic in Agriculture (f), Ethyl, 1946, free loan. The story of chemurgy in agriculture and industry.
Making Atomic Energy Help Mankind (fs), Popular Science, 1950. Explains formation of radioactive isotopes used in medicine and biology.
Oxygen and Hydrogen (fs), Soc. for Visual Ed., 1948. Importance of these gases and their relation to combustion and oxidation.
Physical and Chemical Changes in Everyday Living (3 fs): *Things in the World Change; Changes All Around Us; Your Changing World,* Popular Science, 1951. Presents many activities and experiments.
Radiation—Silent Servant (f), Handel, 1955. Examples of controlled radiation in different fields.
World That Nature Forgot (f,c), Modern Talking Picture, 1955, free

loan. Atoms and molecules and their union to form organic and plastic products.

Communication and Transportation

Basic Telephony (f), U.S. Army Training Film, 1949, free loan. An introduction to telephone communication.
**Behind Your Snapshot* (f,c), Eastman Kodak, free loan (Ch. 28).
**Bottle of Magic* (f), Western Electric, free loan (Ch. 30).
**Calling Your Neighbor* (fs,c), Harbrace (Ch. 27).
**Curves of Color* (f,c), General Electric, free loan (Ch. 29).
**Dialing the Nation* (f), Bell Telephone, free loan (Ch. 27).
**Ears and Hearing* (f), EBF (Ch. 25).
**Highways for the Telephone* (f), Bell Telephone, free loan (Ch. 27).
History of Transportation and Communication (4 fs): *History of Land Transportation; History of Water Transportation; Air Transportation; Early Communication,* YAF, 1946.
How We Produce Sound and Speech (fs), Popular Science, 1951.
Learning About Light (f), EBF, 1955. Practical applications of light phenomena in optics and everyday life.
**Light* (fs,c), YAF (Ch. 26).
**Light Control through Polarization* (f), Polaroid, free loan (Ch. 26).
**Light Waves and Their Uses* (f), EBF (Ch. 26).
**Magic in the Air* (f), General Motors, free loan (Ch. 30).
Mass Communication Series (2 fs): *Radio; Television*, YAF, 1953.
Naturally It's FM (f), General Electric, 1947, free loan. Differences between AM and FM radio.
The Nature of Sound (f), Coronet, 1948 (also f,c). The speed of sound, oscilloscope patterns, and transmission of sound.
**Safe Passage* (f,c), Raytheon, free loan (Ch. 30).
**Sentinel in the Sky* (f,c), Pan American, free loan (Ch. 30).
**Sightseeing at Home* (f), General Electric, free loan (Ch. 20).
**Sound Recording and Reproduction* (f), EBF (Ch. 28).
Sound Waves and Their Sources (f), EBF (Ch. 25).
Stepping Along with Television (f), Bell Telephone, rev. 1955, free loan. How programs are delivered by coaxial cable and radio relay.
Ultra Sounds (f), Almanac, 1951. Ultrasonics in industry and medicine.
Vacuum Tubes (f), EBF (Ch. 30).

Conservation

And on the Seventh Day (f), Northwestern Bell Telephone, free loan. Flood control.
**The Battle of the Beetles* (f,c), U.S. Forest Service, free loan (Ch. 21).
**Bounty of the Forest* (f,c), Western Pine, free loan (Ch. 21).
**County Agricultural Agent* (f,c), Venard, free loan (Ch. 19).
**Food and Soil* (f); **Muddy Waters* (f); **Raindrops and Soil Erosion* (f,c), all on free loan from the U.S. Soil Conservation Service (Ch. 19).
Forest Resources (fs,c), Curriculum, 1951. Results of unregulated cutting of our forests, and steps now being taken to protect them.
**Man's Problems* (f,c), EBF (Ch. 21).
Nitrogen Cycle (f), UWF, 1953.

Raindrops and Soil Erosion (f,c), Soil Conservation Service, U.S. Dept. of Agriculture, 1947.

**Soil Conservation Series* (8 fs), EBF (Ch. 19): *How Long Will it Last?; How Soil is Formed; Plant Life and the Soil; Water and the Soil; Animal Life and the Soil; Minerals in the Soil; How Man Has Used the Soil;* and *How Man Conserves the Soil.*

What Is Soil? (fs), Popular Science, 1950. Explains composition of soil, various types, and plants that grow in each type.

Electricity and Magnetism

Basic Electricity (f), Dept. of the Air Force, 1948, free loan.

**Electromagnets* (f and fs,c), YAF (Ch. 27).

Electrostatics (f), EBF, 1950.

Elementary Electricity: Amperes, Volts, Ohms (f), U.S. CAA, free loan.

Elementary Electricity: Current and E.M.F. (f), U.S. CAA, free loan.

Energy Unlimited (fs,c), Harbrace, 1957.

Fundamentals of Electricity (fs), Photo Lab., 1950. Explains uses of electricity in communication, home, and industry.

Introduction to Electricity (f,c), Coronet, 1948.

Making Electricity (f), EBF, 1949. A simple approach from the hand-operated generator to the great hydroelectric plants.

Principles of Electricity (f,c), General Electric, 1945, free loan.

Story of the Storage Battery (f), U.S. Bureau of Mines, 1947, free loan.

What Is Electricity? (f), Westinghouse, 1944, free loan.

Energy, Matter, and Gravity

**Carbon and Its Compounds* (f), Coronet (Ch. 16).

**Energy from the Sun* (f), EBF (Ch. 22).

**Energy Unlimited* (fs,c), Harbrace (Ch. 23).

Gravity (f,c), Coronet, 1950.

Man's Use of Power (fs), Popular Science, 1950. Defines energy and shows various types of energy, including atomic energy.

**Matter and Energy* (f,c), Coronet (Ch. 14).

**Nature of Energy* (f,c), Coronet (Ch. 22).

**The Strange Case of the Cosmic Ray* (f,c), Bell Telephone, free loan (Ch. 29).

**Water* (fs), Soc. for Visual Ed. (Ch. 16).

What Is Horsepower? (fs), Popular Science, 1950.

Fire and Heat

Fire (f), EBF, 1947. With the aid of animated drawings, the essentials of combustion are shown.

**Fuels and Heat* (f and fs), EBF (Ch. 23).

Heat and Its Control (f), U.S. Bureau of Mines, 1942, free loan. Types and uses of insulating materials.

**Heat—Its Nature and Transfer* (f), EBF (Ch. 13).

**How to Fight a Fire in the Kitchen* (f), Bureau of Communications Research, free loan through Natl. Board of Fire Underwriters (Ch. 13).

**Learning About Heat* (f), EBF (Ch. 13).

Nature of Heat (f,c), Coronet, 1953. Discusses and shows experimentally heat as energy, and how heat is transferred.

**Our Common Fuels* (f,c), Coronet (Ch. 23).

Until the Fire Department Arrives (f), Bureau of Communications Research, National Board of Fire Underwriters, 1953, free loan. Shows how the person at home can help save lives and property before a fire is out of control.

Geology

Birth of a Volcano (f), Sterling, 1947. The development of the volcano from its eruption to its present size (Paricutin in Mexico).

Changing Surface of the Earth (fs,c), Popular Science, 1953.

**Earth and Its Wonders Series* (4 fs,c), EBF (Ch. 8): *Story of Volcanoes; Story of Ice and Glaciers; Story of Mountains;* and *Story of Rivers*.

The Earth's Skin (f), Almanac, rev. 1957. Study of the earth's surface. Reveals rock strata and effects of glaciers.

Fossil Story (f,c), Shell, 1953, free loan. Types of fossils; their use in plotting the story of life on the earth; their value to the oil industry.

Geology (fs,c), Teaching Aids Lab., Ohio State University. Elementary facts about geologic forces on the earth's surface.

How Rocks Are Formed (fs), Jam Handy, 1947. Introduces the study of rocks, their differences, and uses of common rocks.

**Oil: From Earth to You* (fs), Am. Petroleum Inst., free copy for school library (Ch. 17).

**Petroleum in Today's Living* (fs), Am. Petroleum Inst., free (Ch. 17).

**Tides* (f), Almanac (Ch. 8).

Health

Alcohol and Narcotics (4 fs,c): *Alcohol and You* (parts 1 and 2); *Narcotics and You* (parts 1 and 2), YAF, 1953.

Alcohol and Tobacco: What They Do to Our Bodies (f,c), Coronet. How alcohol slows mental speed and affects skill; how nicotine makes blood vessels contract, producing unsteadiness and fatigue.

**City Water Supply* (f), EBF (Ch. 6).

**Clean Waters* (f,c), General Electric, free loan (Ch. 6).

**Community Health in Action* (f,c), Orleans (Ch. 6).

Drug Addiction (f), EBF, 1952. Hazards of drug addiction; its effects shown through the experiences of a youthful addict.

**Eyes and Their Care* (f), EBF (Ch. 25).

**From One Cell* (f,c), Am. Cancer Soc., free loan (Ch. 5).

**Good-by, Mr. Germ* (f), Natl. Tuberculosis Assoc., free loan (Ch. 5).

Good Health Series (6 fs,c): *You and Your Clothes; Pesky—the Cold Bug; You and Your Food; Your Posture—Good and Bad; Bacteria—Good and Bad; Insect Pests and Disease*, YAF, 1952.

H—The Story of a Teen-age Drug Addict (f), YAF, 1951.

Health Adventures (9 fs,c): *Your Bones and Muscles; Your Heart and Lungs; Sleep and Rest; Your Nose and Throat; Your Skin and Its Care; Your Food and Digestion: How Your Ears Work; Your Eyes at Work; Your Teeth and Their Care*, Jam Handy, 1950.

**Health Heroes* (fs), Metropolitan Life Insurance, free (Ch. 5).
How Vitamins Help Man (fs,c), Popular Science, 1951. What the body does with carbohydrates, proteins, fats, minerals, and vitamins.
Introductory Physiology Series (7 fs,c): *Bones and Muscles; Circulatory System; Respiratory System; Digestive System; Skin, Hair, and Nails; The Ears; Nervous System*, YAF, 1951.
**Making Water Safe to Drink* (fs), Popular Science (Ch. 6).
**Man's Greatest Friend* (f), TFC, (Ch. 5).
**The Traitor Within* (f,c), Am. Cancer Soc., free loan (Ch. 5).
**Water Supply* (fs), Academy (Ch. 6).
**What Is Disease* (f,c), Inst. Inter-Am. Affairs (Ch. 5).
**What Makes Us Grow* (f), Natl. Film Board of Canada (Ch. 3).
**Winged Scourge* (f,c), Inst. Inter-Am. Affairs (Ch. 5).
Your Cleanliness (f), YAF, 1953. Cleanliness as a protection against disease; personal habits in care of teeth, hair, skin, and clothing.
Your Food (f), YAF, 1953. Uses both live action and puppets to explain uses of basic nutrients.
Your Posture (f), YAF, 1953. Demonstrates habits and importance of good posture.

Machines and Power

**The ABC of the Automobile Engine* (f,c), General Motors, free loan (Ch. 24).
**The ABC of Internal Combustion* (f,c), General Motors, free loan (Ch. 23).
**Automatic Transmissions* (f), Ford, free loan (Ch. 24).
**The Diesel Story* (f), Shell, free loan (Ch. 23).
**How the Airplane Flies* (f), Shell, free loan (Ch. 24).
**Jet Power* (f), General Electric, free loan (Ch. 24).
**Jet Propulsion* (f), General Electric, free loan (Ch. 24).
**Machines Do Work* (f), YAF (Ch. 22).
**Simple Machines* (f and fs), EBF (Ch. 22).

Medicine and Physiology

**Antibiotics* (f), EBF (Ch. 5).
Body Defenses Against Disease (fs,c), Universal, 1950.
**Circulation* (f), Am. Heart Assoc., free loan (Ch. 4).
**Circulation* (f), UWF (Ch. 4).
Common Cold (fs), EBF, 1951.
**Digestion of Foods* (f), EBF (Ch. 4).
**Foods and Nutrition* (f), EBF (Ch. 3).
**Heart—How It Works* (f), McGraw (Ch. 4).
**Hemo the Magnificent* (f,c), Bell Telephone, free loan (Ch. 4).
**How the Eye Functions* (f), Knowledge Builders (Ch. 26).
Human Body: Skeleton (f), Coronet, 1953. Skeletal structure viewed by means of fluorography.
**The Nervous System* (f), EBF (Ch. 1).
**Problem-Solving in Infants* (f,si), Int. Film Bureau (Ch. 1).
Respiratory System (fs,c), YAF, 1951. Its structure, function, and care.
Wonder Engine of the Body (f), Bray, 1951. Anatomy, physiology, and proper care of the heart.

Your Bones (fs,c), Curriculum, 1951. Elementary explanation of the body's skeletal structures and functions.
**Your Eyes at Work* (fs,c), Jam Handy (Ch. 26).
**Your Life Stream* (fs,c), Harbrace (Ch. 4).
Your Muscles (fs,c), Curriculum, 1951. Action of voluntary and involuntary muscles.

Microscope Study

**Cell—The Structural Unit of Life* (f,c), Coronet (Ch. 3).
The Compound Microscope (f,c), Bausch and Lomb, 1953, free loan.
Compound Microscope (fs), Visual Ed. Consultants, 1952. Explains parts and use of the microscope.
Microscope and Its Use (f), YAF, 1949. Fundamental parts of the microscope; its use and care.
Microscopic Wonders in Water (f,c), Dowling, 1953. Typical microscopic animals found in a drop of water.

Plant Life

**The Atomic Greenhouse: Tagging the Atom* (f), AEC, free loan (Ch. 18).
Food from the Sun (fs,c), Sugar Information, 1948, free loan. Process of photosynthesis; discussion of carbohydrates and nutrition.
**Gift of Green* (f,c), N.Y. Botanical Garden (Ch. 18).
**Green Plants—Food Factories for the World* (fs,c), Harbrace (Ch. 18).
How Plants Grow and Reproduce (fs,c), Soc. for Visual Ed., 1951.
Hunger Signs in Corn (fs), De Kalb Agricultural Assoc., 1952, free.
Kinds of Plants (fs,c), Soc. for Visual Ed., 1951. Characteristics and structures of algae and fungi, mosses and liverworts, ferns and seed plants.
**Leaves* (f), EBF (Ch. 18).
Life of a Plant (f,c), EBF, 1950. Life cycle of a typical flowering plant, the pea.
Parts of a Flowering Plant (fs,c), Curriculum, 1951.
**Photosynthesis* (f), UWF (Ch. 18).
Plant Growth (f), EBF. Seed germination, actual growth, opening of the flower, floral parts, cross-pollination, and streaming of protoplasm in pollen tubes.
Roots of Plants (f,c), EBF, rev. 1957. Kinds of roots, how they serve to hold the plant in place, and how they absorb minerals.

Reproduction and Heredity

Alaska's Silver Millions (f), American Can, 1936, free loan. Life history of the salmon.
Biography of the Unborn (f), EBF, 1956. From fertilization to the moment when the infant begins independent life.
**Breeding Better Food Crops* (f,c), Natl. Garden Bureau (Ch. 20).
Development of the Chick Embryo (f,c), Coronet, 1953. Photomicrographs of stages of chick embryology; scenes of chick hatching.
**Development of the Frog* (f), UWF (Ch. 20).
**Flowers at Work* (f,c), EBF (Ch. 20).

Heredity (fs), Popular Science, 1950.
Heredity and Environment (f,c), Coronet, 1951. Living things which are the product of their heredity and environment.
Human Development (f,si), Bray, 1939. Fertilization of egg and development of embryo in animated drawings. Embryo stages in photographs.
Human Growth (f,c), Brown Trust, 1948. An animated film which traces human growth and development, from mating through pregnancy and birth. Differences in male and female development emphasized. A mixed group of junior high school children are seen asking questions.
Improving Chickens by Crossing Inbreds (f,c), Hy-Line, 1948, free loan.
**Improving Strains of Livestock* (f), EBF (Ch. 20).
Judging Dairy Cattle (fs), American Guernsey Cattle Club, 1951.
**Life of the Honey Bee* (fs,c), Soc. for Visual Ed. (Ch. 21).
Metamorphosis (fs,c), *Life* Magazine, 1952. Life cycle of *Cecropia* moth. Bright students will delight in the second portion, which shows procedures and findings on hormones that control metamorphosis. Developed from the story "Why Insects Change Form" (*Life* Magazine, Feb. 11, 1952). The edited notes of Dr. Carroll Williams (Harvard University), who did the *original* research on both story and filmstrip, are sent with the filmstrip.
Monarch Butterfly Story (f,c), EBF, 1950. Life cycle of monarch butterfly; photographs of chrysalis formation and emergence of adult.
New Chicken (fs,c), De Kalb Agricultural Assoc., 1952, free loan.
Operation of a Forest Nursery (f), U.S. Forest Service, 1948, free loan.
Reproduction Among Mammals (fs), EBF, 1948. Based on film of same title. Major stages in mammal reproduction from sex cell formation to birth, as illustrated by the pig.
Sexual Reproduction in Plants (fs), De Kalb Agricultural Assoc., 1952, free loan.
The Story of the Bees (f), UWF, 1948. Life history of the bee.
Story of Menstruation (f,c), Association, 1947, free loan. A Walt Disney animated film explains physiology of menstruation. Methods of care and hygiene are stressed.
Where New Flowers Are Bred (f,c), Natl. Garden Bureau, 1948.

Science and Scientists

Louis Pasteur—Man of Science (f), Sterling, 1951. His accomplishments in chemistry and microbiology.
Man Against Microbe (f), Metropolitan Life Insurance, 1932, free loan. The work of Leeuwenhoek, Pasteur, Lister, Koch, and von Behring.
New Frontiers of Medicine (f), McGraw, 1948.
New Frontiers of Science (fs), New York *Times*, 1953. The achievements and problems of scientists.
Scientific Methods (f), EBF, 1954.
**The Scientist—His Way, Your Way* (fs,c), Harbrace (Ch. 1).
Youthful Scientists (fs), Photo Lab., 1950. Produced by Science Service.

Weather and Climate

Atmosphere and Its Circulation (fs), General Science Series, EBF, 1950.
Climate (f,c), Coronet. Elementary explanations of factors of climate.

Clouds (f), Almanac, 1951. Why there are clouds and how they are formed. Time-lapse photography.

Clouds, Rain, and Snow (fs,c), Soc. for Visual Ed., 1950. Very simple presentation of formation and kinds of clouds; precipitation; rainbows and lightning.

**How Weather Is Forecast* (f,c), Coronet (Ch. 11).

Hurricane Circuit (f), UWF-Govt., 1949, free loan.

**Nature's Plan* (f,c), EBF (Ch. 10).

Our Ocean of Air (fs), Soc. for Visual Ed., 1949. Air, instruments, composition, and pressure.

Our Weather (f), EBF, 1955. Effect of good and bad weather on man's activities; air mass theory; weather observation instruments; forecasts, as given on television.

**The Seasons* (fs,c), YAF (Ch. 12).

Seasons, Weather, and Climate Series (4 fs,c): *Sun and Our Seasons; What Is Weather?; What Makes Weather; Climate,* Jam Handy, 1952.

Story of a Storm (f,c), Coronet, 1950. Conditions that cause a rainstorm to develop. Pressure areas, fronts, and weather instruments.

Thunder and Lightning (f), YAF, 1950. Simple approach that brings in static electricity. Protective measures to take in an electrical storm.

Tornado (f), U.S. Weather Bureau, 1956, free loan. Tornadoes and weather conditions that cause them.

**Unchained Goddess* (f,c), Bell Telephone, free loan (Ch. 10).

**Warning Tornado* (f), Dept. of the Air Force, free loan (Ch. 11).

**Weather* (f), Almanac (Ch. 11).

The Weather (f), EBF, 1942. Polar-front weather theory.

The Weather (8 fs,c): *Sun, Weather Maker; Air in Action; Water in Weather; Thunderstorms; Weather and People; Weather Bureau; Weather Maps; Be Your Own Weather Man,* Curriculum, 1952.

Weather Men of the Sea (f), U.S. Coast Guard, 1950, free loan. Activities of a weather ship in the stormy North Atlantic waters.

What Makes a Desert? (f), YAF, 1949. Special attention to deserts in southwestern United States.

What Makes Rain (f), YAF, 1947. A simple presentation of the water cycle.

Winds and Their Causes (f,c), Coronet, 1948. Heat currents and thunderstorms in animated sequences; causes of easterly and westerly winds.

SCIENCE REFERENCE SHELF

Many of the books listed will no doubt be familiar to you. You may want to develop a science library, or a science shelf in the school library, for yourself or your classroom. Community libraries welcome suggestions from the science teacher for new titles.

The pupils, especially the science-prone, will look to you for suggestions for developing their background through reading, as well as for expanding their own individual libraries. For pupils

(and teachers) with limited finances, the many paperbacked science books can help build up the beginnings of an adequate library.

Books that are easily available in classroom, school, and home will enable children to seek out information readily—rather than depend on the teacher completely. Encouraging independence of investigation goes with the development of good book-reference habits.

Animals and Animal Functions

Hoke, J., *The First Book of Snakes*, Watts, 1952. A beginner's book on recognition of kinds of snakes and their behavior and habits.

Insects, 1952 Yearbook of Agriculture, U.S. Department of Agriculture. Excellent, concise articles; full-page color illustrations.

Klots, A. B., *The World of Butterflies and Moths*, McGraw, 1958. Many full-page color photographs of North American specimens.

McClung, R., *All About Animals and Their Young*, Random, 1958. Breeding, incubation, and weaning are some of the patterns disclosed.

Palmer, E. L., *Field Book of Natural History*, McGraw, 1949. Extensive coverage of many fields; excellent reference.

Teale, E. W., *The Junior Book of Insects*, Dutton, 1953. Lives and habits of common insects; instructions for collecting, rearing, and studying.

Zim, H. S., and C. Cottam, *Insects*, Simon and Schuster, 1951. Handy, well-illustrated reference on common insects.

Zim, H. S., and H. M. Smith, *Reptiles and Amphibians* Simon and Shuster, 1953. Excellent reference for both teacher and pupil.

Astronomy

Adler, I., *The Stars*, Day, 1956. Reasoning and evidence of the astronomer which lead to their conclusions about the stars.

Heuer, K., *An Adventure in Astronomy*, Viking, 1958. A tour of the skies and the effect on earth of heavenly bodies.

Hoyle, F., *Frontiers of Astronomy*, New American Library, 1955.

Hoyle, F., *The Nature of the Universe*, Harper, 1951 (also available as a Mentor paperback book).

Hyde, M. O., *Exploring Earth and Space*, Whittlesey, 1957. Excellent presentation of the IGY.

Johnson, G., and I. Adler, *Discover the Stars*, Sentinel Books, 1958. How to build a planetarium, sundial, etc.

Scientific American Editors, *The New Astronomy*, Simon and Schuster, 1955.

Scientific American Editors, *Planet Earth*, Simon and Schuster, 1957.

Scientific American Editors, *The Universe*, Simon and Schuster, 1957.

Skilling, W. T., and R. S. Richardson, *Sun, Moon, and Stars*, McGraw, 1946. A well-written, authentic book with good diagrams.

Spilhaus, A., *Satellite of the Sun*, Viking, 1958. The sun and its effects on the earth.

Watson, F. G., *Between the Planets*, Harvard University Press, 1956.

Zim, H. S., and R. H. Baker, *Stars,* Golden Nature Guide, Simon and Schuster, 1951. A pocket guide to constellations, the moon, sun, and solar system.

Atomic Energy

Amrine, M., *The Great Decision,* Putnam, 1959. The story of the atom bomb.
Asimov, I., *Inside the Atom,* 2nd edition, Abelard-Schuman, 1956. Atoms and the uses of atomic energy.
Bischof, G. P., *Atoms at Work,* Harcourt, Brace, 1951.
Eidinoff, M. L., and H. Ruchlis, *Atomics for the Millions,* McGraw, 1947. By means of cartoons, the authors illustrate the story and uses of atomic energy.
Fermi, L., *Atoms for the World,* University of Chicago Press, 1957. The life of the famous nuclear physicist Enrico Fermi.
Freeman, I. M., *All About the Atom,* Random, 1955.
Haber, H., *Our Friend the Atom,* Simon and Schuster, 1957.
Hecht, S., *Explaining the Atom,* rev. edition, Viking, 1954.
Hyde, M. O., *Atoms Today and Tomorrow,* Whittlesey, 1955.
Laurence, W. L., *Dawn over Zero*, Knopf, 1947. An eye-witness account of the explosion of an atomic bomb.
Mann, M., *Peacetime Uses of Atomic Energy,* Crowell, 1957.
May, J., *There's Adventure in Atomic Energy,* Popular Mechanics, 1957.
Sacks, J., *The Atom at Work,* Ronald Press, 1951. Constructive uses of atomic energy.
Teller, E., and A. Latter, *Our Nuclear Future,* Criterion, 1958. The physical laws and happenings of modern nuclear science.

Aviation

Bergaust, E., *Rockets and Missiles,* Putnam, 1957. A short, simple book; photographs and diagrams.
Knight, C., *The Story of Flight,* Grosset, 1954.
Schneider, L., and M. U. Ames, *Wings in Your Future,* Harcourt, Brace, 1955. Various forms of air travel.
Well, R., *What Does a Jet Pilot Do?* Dodd, 1959. Accounts of jet engines, jet planes, and the role of the pilot.
Winter, W., *The Model Aircraft Handbook,* 4th edition, Crowell, 1957.

Biological Sciences (General)

Jordan, E. L., *Hammond's Nature Atlas of America,* C. S. Hammond, 1952. Illustrations in color: trees, wildflowers, minerals and rocks, animals of various classes.
Morholt, E., P. F. Brandwein, and A. Joseph, *A Sourcebook for the Biological Sciences,* Harcourt, Brace, 1958. A valuable tool for the teacher who is eager to develop new approaches to many topics.
Parker, B. M., *The Golden Treasury of Natural History,* Simon and Schuster, 1952. Beautifully illustrated with colored paintings.
Simpson, G. G., C. Pittendrigh, and L. Tiffany, *Life: An Introduction to College Biology,* Harcourt, Brace, 1957. Excellent reference on up-to-date biological topics.

Smith, E. T., *Exploring Biology,* 5th edition, Harcourt, Brace, 1959. Material on heredity, fossils, reproduction, and conservation, for students who want to explore these topics.
Turtox Science Leaflets, General Biological Supply House, 8200 S. Hoyne Avenue, Chicago 20, Ill. Free set of over fifty topics to science teachers. Useful for student projects.
Worth, C. B., and R. K. Enders, *The Nature of Living Things,* New American Library, 1955. A Signet Key paperback which explores the plant and animal kingdoms.

Careers in Science

A Career in Engineering, American Job Series 30, 1942; *Careers in Public Health* by A. Gould, 1947; *Choosing Your Career* by J. A. Humphreys, Life Adjustment Booklet, 1949; *Discovering Your Real Interests,* by F. Kuder and B. Paulson, 1949; *Four-square Planning for Your Career* by S. A. Hamrin, 1946; *Handbook of Job Facts* by A. Frankel, 1948; *Opportunities in Farming* by P. Chapman, 1947, and *Physicians and Surgeons,* 1943; all Science Research Associates pamphlets, Chicago.
Encouraging Future Scientists: Keys to Careers, Natl. Science Teachers Assoc., 1959.
Outlook for Women in Biological Sciences, Women's Bureau Bulletin 223-3, 1948.
Outlook for Women in Occupations Related to Science, Women's Bureau Bulletin 223-8, U.S. Department of Labor, U.S. Government Printing Office, Washington, D.C., 1949.
Pollack, P., *Careers and Opportunities in Engineering,* Dutton, 1958. A look at job approaches in such professions as civil engineering, petroleum engineering, and others.
Pollack, P., *Careers and Opportunities in Science: A Survey of All Fields,* Dutton, 1954.
Pollack, P., *Your Career in Physics,* Dutton, 1955.
Veterinary Medicine as a Career, Am. Veterinary Medical Assoc., Chicago, 1947.

Chemistry

Beeler, N. F., and F. M. Branley, *Experiments in Chemistry,* Crowell, 1952. Common phenomena and things explained in terms of simple chemistry experiments.
Freeman, M. and I. M., *Fun with Chemistry,* Random, 1944. Very easy experiments, many with full-page illustrations, will help the teacher plan for the slow learner.
Jaffe, B., *Chemistry Creates a New World,* Crowell, 1957.
May, J., *There's Adventure in Chemistry,* Popular Mechanics, 1957.
Morgan, A., *First Chemistry Book for Boys and Girls,* Scribner, 1950. A book of directions for simple chemistry experiences.
Morgan, A., *Getting Acquainted with Chemistry,* Appleton, 1942. Simple experiments; directions for setting up a laboratory at home.
Morgan, A. P., *Things a Boy Can Do with Chemistry,* Appleton, 1940.

Conservation

Allen, S. W., *Conserving Natural Resources*, McGraw, 1955.
Bennett, H. H., *Elements of Soil Conservation*, 2nd edition, McGraw, 1955.
Black, J. D., *Biological Conservation*, McGraw, 1954.
Outline for Teaching Conservation in the High School, free pamphlet from U.S. Dept. of Agriculture, Soil Conservation Service.
Soil (1957); *Land* (1958), Yearbooks of Agriculture, U.S. Dept. of Agriculture, Washington, D. C.
Water, 1955 Yearbook of Agriculture, U.S. Dept. of Agriculture, 1955.
Storer, J. H., *The Web of Life*, New American Library, 1956. Excellent paperback on conservation; with illustrations.
Watts, M. T., *Reading the Landscape*, Macmillan, 1957.
Weaver, R. (project leader), *Handbook for Teaching of Conservation and Resource-Use*, Natl. Assoc. of Biology Teachers, Ann Arbor, Mich, 1955.

Electricity and Magnetism

Beeler, N. F., and F. M. Branley, *Experiments with Electricity*, Crowell, 1949. Clear directions for setting up electrical experiments.
Cook, S. R., *Things to Make with Dry Batteries* (90-page pamphlet), Burgess Battery Co., Freeport, Ill. Directions for many projects with dry batteries.
Efron, A., *Basic Physics*, Rider, 1957. Chapters 16 and 17 discuss magnetism and electrostatics.
Electrical Fundamentals, Chrysler, free booklet.
Elliot, L. P., and W. F. Wilcox, *Physics: A Modern Approach*, Macmillan, 1957. Chapters 30-33 include material on static electricity and magnetism.
Epstein, S., and B. Epstein, *The First Book of Electricity*, Watts, 1953.
Freeman, I. M., *All About Electricity*, Random, 1957.
How to Build an Electric Motor, Westinghouse, free booklet on construction of a simple electric motor.
Magnetism and Electricity, Chrysler, free booklet.
Safe Use of Electrical Equipment, Natl. Education Assoc., Washington, D.C., 1951. An important booklet to teach safe handling of electrical devices.

Electronics, Radio, and Television

The ABC's of Radio, Electronics Dept., General Electric, Schenectady, N.Y.
Bendick, J., *Television Works Like This*, rev. edition, Whittlesey, 1954. Many cartoons.
Cook, J. G., *Electrons Go to Work*, Dial, 1957. Chapters 10, 12, and 13 discuss radar and television.
Gould, J., *All About Radio and Television*, Random, 1953. An excellent book, simply written; clear diagrams, directions for experiments.
Marcus, A., *Radio Projects*, Prentice-Hall, 1956.
Marcus, A., *Elements of Radio*, 3rd edition, Prentice-Hall, 1953.
Morgan, A. P., *The Boys' Second Book of Radio and Electronics*, Scribner, 1957.
Ross, F., Jr., *Radar and Other Electronic Inventions*, Lothrop, 1954.

Electronic devices used in military, navigational, communication, and medical fields.

Experiments in Science

Goldstein, P., *How to Do an Experiment,* Harcourt, Brace, 1957. An introduction to the methods of science; how information is obtained, and how to carry on an investigation. Excellent for teachers, pupils, and science clubs concerned with projects or science fairs.

Lynde, C.J., *Science Experiences with Home Equipment,* 2nd edition, International Textbook Co., 1949. Two hundred science experiments, all illustrated.

Lynde, C. J., *Science Experiences with Inexpensive Equipment,* 2nd edition, International Textbook Co., 1950. Two hundred experiments, some simple, others more difficult, to demonstrate the concepts in the study of heat, air and water pressure, liquids, and gases; the principles underlying baseball pitching and batting.

Lynde, C. J., *Science Experiences with Ten-Cent Store Equipment,* 2nd edition, International Textbook Co., 1950.

Swezey, K. M., *After-Dinner Science,* McGraw, 1948. Many full-page photographs describe simple home science experiences.

Fire and Heat

Adler, I., *Fire in Your Life,* Day, 1955. Discussion of fuels and fire.

Branley, F. M., *Solar Energy,* Crowell, 1957. Many striking examples of the use of solar energy.

Fire Prevention Education, Natl. Board of Fire Underwriters, 85 John Street, New York, N.Y., 1945. Suggestions for home safety and fire inspections.

Parker, B. M., *Heat,* Row, Peterson, 1942. A Basic Science Education Series booklet.

Gardening

Bush-Brown, L. and J., *America's Garden Book,* rev. edition, Scribner, 1958.

Young, P. R., *Elementary Lessons in Gardening,* Natl. Garden Inst., 1368 N. High St., Columbus, Ohio, 1953. Growing plants in house and garden.

Geology

Baity, E. C., *America Before Man,* Viking, 1953. A good book giving the geological changes and the development of life up to the era of prehistoric man.

Barnett, L., *The World We Live In,* Simon and Schuster, 1956.

Croneis, C., and W. C. Krumbein, *Down to Earth,* University of Chicago Press, 1950.

Fenton, C. L. and M. A., *The Fossil Book,* Doubleday, 1958. A comprehensive survey of fossils.

Fenton, C. L. and M. A., *Riches from the Earth,* Day, 1953. Uses of minerals and ores.

Fenton, C. L. and M. A., *Rocks and Their Stories,* Doubleday, 1951. Identification of rocks and minerals.

Irving, R., *Rocks and Minerals,* Knopf, 1956.
Marshack, A., *The World in Space,* Dell, 1958.
Martin, C. M., *Monsters of Old Los Angeles,* Viking, 1950. The prehistoric animals of the La Brea (tar) pits.
Moore, P., *The Earth, Our Home,* Schuman-Abelard, 1957. Introduction to the International Geophysical Year (IGY) and the study of the earth.
Namowitz, S. N., and D. B. Stone, *Earth Science,* Van Nostrand, 1953.
Pearl, R. M., *How to Know the Minerals and Rocks,* McGraw, 1955.
Pough, F. H., *All About Volcanoes and Earthquakes,* Random, 1953. Authentic, nontechnical, and readable.
Schneider, H. and N., *Rocks, Rivers, and the Changing Earth,* W. R. Scott, 1952.

Growth and Development—Human

Burnett, R. W., J. W. Clemensen, and H. S. Hoyman, *Life Goes On,* Harcourt, Brace, 1959.
Fedder, R., *A Girl Grows Up,* 3rd edition, McGraw, 1957. Helpful for the teacher in getting to understand the adolescent girl.
McKown, H. C., *A Boy Grows Up,* McGraw, 1949.
Scheinfeld, A., *The New You and Heredity,* Lippincott, 1950. An excellent book; many topics on development and on man's inheritance of specific traits.

Health and the Human Body

Best, C. H., and N. B. Taylor, *The Living Body,* 3rd edition, Holt, 1952.
Clemensen, J. W., and others, *Your Health and Safety,* 4th edition, Harcourt, Brace, 1957. A valuable source of health information.
Cooley, D. G., *The Science Book of Wonder Drugs,* Watts, 1954. Also available as a Pocket Book (paperback).
Cosgrove, M., *Wonders of Your Senses,* Dodd, 1958. A stimulating approach to the sensory mechanisms of the body.
The Endless Frontier, Health Information Foundation, 420 Lexington Avenue, New York 17, N.Y., free pamphlet. Stories of progress in heart disease, cancer, nutrition, and surgical care on the battlefront.
Gerard, R. W. (ed.), *Food for Life,* University of Chicago Press, 1952. (A free paperback edition from the Continental Baking Company is available to teachers.) A 306-page book which covers nutrition, enzymes, cell metabolism, energy and growth, and improvement of human nutrition.
Hyde, M. O., *Medicine in Action,* Whittlesey, 1956. Health practices, including research methods.
Schneider, H. and N., *How Your Body Works,* W. R. Scott, 1949. Simple experiences help the reader understand the functioning of the body.
Schneider, L., *You and Your Senses,* Harcourt, Brace, 1956. The operation and care of the human sensory machinery.
Sproul, E., *The Science Book of the Human Body,* Watts, 1955. Also available as a Pocket Book (paperback).
Tokay, E., *The Human Body and How It Works,* New American Library, 1958. Vital facts about the heart and various body organ systems, plus helpful data on diet, exercise, and rest. Forty-four illustrations and a 24-page anatomical atlas.

Your Child's Teeth, Committee on Dental Health Education, Am. Dental Assoc., 1940.
Youth Looks at Cancer, Am. Cancer Soc., free pamphlet.

Hobbies

Brown, V., *How to Make a Home Nature Museum,* Little, 1954. A handbook for the amateur naturalist.
Gilmore, H. H., *Model Planes for Beginners,* Harper, 1947. How to make some of the simpler models.
Jensen, D. E., *My Hobby Is Collecting Rocks and Minerals,* Hart, 1955.
Klots, A. B., *Directions for Collecting and Preserving Insects,* Ward's Natural Science Establishment, Rochester, N.Y. Detailed instructions for collecting, mounting, pressing insects.
Morgan, A., *A Pet Book for Boys and Girls,* Scribner, 1949.
Musciano, W. A., *The Model Plane Manual,* McBride, 1952. Tells how to make many free-flight and control-line models; also lists tools and materials.
Pearl, R. M., *How to Know the Minerals and Rocks,* McGraw, 1955.
Zarchy, H., *Let's Make a Lot of Things,* Knopf, 1948. Crafts for home, school, and camp.
Zim, H. S., *Plants: A Guide to Plant Hobbies,* Harcourt, Brace, 1947.
Zim, H. S., and P. R. Shaffer, *Rocks and Minerals,* Simon and Schuster, 1957.

Light and Vision

Eyes, Our Windows to the World, Better Light Better Sight Bureau, 750 Third Avenue, New York 17, N.Y., free bulletin.
Perry, J., *Our Wonderful Eyes,* Whittlesey, 1955. Experiments to help understand the function of the eye.
Recommended Practice for Residence Lighting, Illuminating Engineering Soc., 1860 Broadway, New York 23, N.Y., 1953. While this booklet is somewhat technical, its tables and charts are valuable in showing the lighting recommended for various rooms in the house.

Methods in Science Teaching

Brandwein, P. F., F. G. Watson, and P. E. Blackwood, *Teaching High School Science: A Book of Methods*, Harcourt, Brace, 1958. See especially Chapter 15, which relates to the general science course.
Burnett, R. W., *Teaching Science in the Secondary School,* Rinehart, 1957.
Richardson, J. S., *Science Teaching in Secondary Schools,* Prentice-Hall, 1957.
Richardson, J. S., and G. P. Cahoon, *Methods and Materials for Teaching of General and Physical Science,* McGraw, 1951. Laboratory experiences, demonstrations, and projects for general and physical science.
Sponsors' Handbook: Thousands of Science Projects, Science Clubs of America, Science Service, 1719 N St., Washington 6, D.C. Contains many hints for getting pupils started on class projects.

Microscopic Life

Schwartz, J., *Through the Magnifying Glass,* Whittlesey, 1954.
How to use a simple magnifying glass to learn more about plants, animals, crystals, etc.

Thone, F., *The Microscopic World,* Messner, 1940.
Very good photomicrographs.

Photography

Abbott, Bernice, *New Guide to Better Photography,* Crown, 1953.
How to take, develop, and print pictures; a section on color photography.

Hoke, J., *The First Book of Photography,* Watts, 1954.
Excellent for the beginning amateur photographer.

Zim, H. S., and R. W. Burnett, *Photography* (a Golden Handbook), Simon and Schuster, 1956. An excellent pocket book with hints on making better pictures, including such special problems as nature photography, photomicrography, telescopic pictures, aerial and infrared shots, and trick photography.

General Physical Science

Brinckerhoff, R., and others, *The Physical World,* Harcourt, Brace, 1959. Clear illustrations and lucid text.

Conant, J. B., *On Understanding Science,* New American Library, 1952.
A lucid explanation of the role of science in modern life.

Huey, E. G., *What Makes the Wheels Go Round,* rev. edition, Harcourt, Brace, 1952. Brief explanations, accompanied by diagrams, of many topics in physical science.

Joseph, A., P. F. Brandwein, and E. Morholt, *A Sourcebook for the Physical Sciences,* Harcourt, Brace, 1960. Many experiences and helpful hints for the teacher of general science.

Poole, L., *Frontiers of Science,* Whittlesey, 1958.
New developments in many science fields.

Plants and Plant Functions

Bonner, J., and A. W. Galston, *Principles of Plant Physiology,* Freeman, 1952.

Hylander, C., *The World of Plant Life,* 2nd edition, Macmillan, 1956.

Meyer, B. S., and D. B. Anderson, *Plant Physiology,* 2nd edition, Van Nostrand, 1952.

Platt, R., *American Trees,* Dodd, 1952. Trees of all parts of the United States.

Wilson, C. L., and W. E. Loomis, *Botany,* rev. edition, Holt (Dryden), 1957. A good source of botanical information, including groups of plants.

Zim, H. S., and C. Martin, *Flowers,* Simon and Schuster, 1950.
A handy pocket book; many colorful illustrations.

Power and Machines

Burlingame, R., *Machines That Built America,* Harcourt, Brace, 1953.
Tells how our important machines were invented.

Reck, F. M. and A. C. Y., *Power from Start to Finish,* Crowell, 1941.
Traces power from the original source—the sun—to its uses in industry.
Rogers, A., *From Man to Machines,* Little, 1941.
The story of the great mechanical inventions; well illustrated.
Schneider, H., *Everyday Machines and How They Work,* Whittlesey, 1950.
Household machines and how they work.
Schneider, H. and N., *More Power to You,* W. R. Scott, 1953.
The development and use of power.
The Story of the Turbine, General Electric, Schnectady, N. Y., free pamphlet.
William-Ellis, A., *Engines, Atoms, and Power,* Putnam, 1958.
An account of the study of the atom in relation to various engines.

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Conant, J. B., *Harvard Case Histories in Experimental Science* (2 vols.), Harvard University Press, 1957. Famous scientists of the past describe their own work.
Gabriel, M., and S. Fogel, *Great Experiments in Biology,* Prentice-Hall, 1955.
Jaffe, B., *Men of Science in America,* Simon and Schuster, 1958.
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Milne, L. J. and M. J., *Famous Naturalists,* Dodd, 1952.
Schwartz, G., and P. W. Bishop, *Moments of Discovery,* (2 vols.), Basic Books, 1958.
Stevens, W. O., *Famous Men of Science,* Dodd, 1952.
Yost, E., *Women of Modern Science,* Dodd, 1959.
Helps to show that women can and do play a role in scientific discovery.

Sound and Hearing

Brentano, L., *Ways to Better Hearing,* Watts, 1946.
For those who have some loss of hearing, this book is helpful.
Kettlekamp, L., *The Magic of Sound,* Morrow, 1956.
The principles and uses of sound.

Space Travel

Caidin, M., *Rockets Beyond the Earth,* McBride, 1953.
Coombs, C., *Rockets, Missiles, and Moons,* Morrow, 1957.
Simple explanations of the forces that move rockets, missiles, and satellites; photographs of the Vanguard satellite.
Haber, H., *Man in Space,* Bobbs-Merrill, 1953.
Examines man's ability to adapt to the conditions of space travel.
Jet Propulsion and Astronautics, American Rocket Society.
Of interest to the rapid learner.
Leonard, J. N., *Flight into Space,* Random, 1953. Also, a New American Library book. The attempts of man to penetrate the universe.
Ley, W., *Man-made Satellites,* Simon and Schuster, 1957.
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Newell, H. E., Jr., *Guide to Rockets, Missiles, and Satellites,* Whittlesey, 1958. Space terms used in illustrative ways; many photographs and diagrams.

Newell, H. E., Jr., *Space Book for Young People,* Whittlesey, 1958. Simple approach to space travel, rockets, and satellites, with some mathematical aspects.

Space Encyclopedia: A Guide to Astonomy and Space Research, Dutton, 1957.

Space Primer: An Introduction to Astronautics, General Dynamics Corp., 1959. A free 72-page booklet on origins of astronautics, escape from earth, propulsion, motion of bodies in space, satellites, travel in the solar system, careers in astronautics, and a glossary and excellent bibliography of books on space topics. Write to Dept. 120, Convair-Astronautics, P.O. Box 1128, San Diego 12, Calif.

Stine, G. H., *Rocket Power and Space Flight,* Holt, 1957.

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Manual of Cloud Forms and Codes for the States of the Sky, U.S. Weather Bureau, Washington, D.C.

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Spilhaus, A., *Weathercraft,* Viking, 1951. How to make and operate an amateur weather station.

Tannehill, I. R., *All About the Weather,* Random, 1953. Nontechnical but authentic; describes methods of reporting and forecasting.

Wexler, H., "The Circulation of the Atmosphere," in Scientific American Book *The Planet Earth,* Simon and Schuster, 1957.

1941 Yearbook of Agriculture: Climate and Man, U.S. Dept of Agriculture, Washington, D.C. Excellent reference, including data on climate for each state.

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TEACHER'S ANSWER KEY TO HARBRACE TEACHING TESTS

The 30 Chapter Tests, the 7 Unit Tests, and the 4 Tests of Interpretation for **You and Science**, both Forms A and B, can be scored by the keys which follow. The Keys to the Form A Chapter Tests and Tests of Interpretation are on Manual pages 228-29 and those for Form B are on pages 230-31. The Keys for Unit Tests, Form A, are on page 232 and those for Form B are on page 233.

To find the proper answer key to a *Chapter*
look for that Test Number (in boldface) at
two pages. To score a test, match the
key, and for every incorrect answer subtract

FORM A

Key to *Chapter Tests* **1**, **7**, **10**, **13**, **17**, **24**, **28**, and *Test of Interpretation* **3**

Question	1.	c
	2.	a
	3.	d
	4.	a
	5.	b
	6.	d
	7.	c
	8.	a
	9.	b
	10.	d
	11.	c
	12.	b
	13.	a
	14.	c
	15.	d
	16.	d
	17.	b
	18.	a
	19.	d
	20.	c

Key to *Chapter Tests* **2**, **5**, **11**, **16**, **20**, **23**, **26**, **29**, and *Test of Interpretation* **4**

Question	1.	b
	2.	c
	3.	a
	4.	c
	5.	d
	6.	c
	7.	b
	8.	d
	9.	b
	10.	a
	11.	b
	12.	a
	13.	d
	14.	c
	15.	b
	16.	a
	17.	c
	18.	b
	19.	a
	20.	d

For Key to *Unit Tests*, Form A, see page 232.

Test or a *Test of Interpretation* in FORM A,
the top of one of the four columns on these
pupil's answers against those in the proper
5 points from a maximum score of 100.

FORM A

Key to *Chapter Tests* **3**, **6**, **9**, **14**, **19**, **22**, **27**, and *Test of Interpretation* **1**

Question	
1.	c
2.	d
3.	a
4.	d
5.	b
6.	a
7.	c
8.	b
9.	a
10.	d
11.	c
12.	d
13.	b
14.	c
15.	a
16.	a
17.	c
18.	d
19.	a
20.	b

Key to *Chapter Tests* **4**, **8**, **12**, **15**, **18**, **21**, **25**, **30**, and *Test of Interpretation* **2**

Question	
1.	b
2.	c
3.	a
4.	d
5.	d
6.	a
7.	c
8.	a
9.	d
10.	b
11.	a
12.	c
13.	b
14.	d
15.	b
16.	a
17.	b
18.	c
19.	a
20.	d

For Key to *Unit Tests*, Form A, see page 232.

To find the proper answer key to a *Chapter*
look for that test number (in boldface) at
pages. To score a test, follow the same

FORM B

Key to *Chapter Tests* **1**, **5**, **9**, **14**, **17**, **22**, **26**, and *Test of Interpretation* **1**

Question	
1.	d.
2.	a
3.	b
4.	c
5.	a
6.	b
7.	c
8.	d
9.	a
10.	b
11.	a
12.	b
13.	d
14.	b
15.	c
16.	d
17.	c
18.	a
19.	c
20.	b

Key to *Chapter Tests* **2**, **7**, **10**, **13**, **18**, **21**, **25**, **29**, and *Test of Interpretation* **4**

Question	
1.	b
2.	a
3.	d
4.	c
5.	a
6.	a
7.	c
8.	b
9.	d
10.	c
11.	d
12.	a
13.	b
14.	c
15.	a
16.	b
17.	d
18.	a
19.	d
20.	c

For Key to *Unit Tests*, Form B, see page 233.

Test or a *Test of Interpretation* in FORM B, the top of one of the four columns on these directions as for FORM A.

FORM B

Key to *Chapter Tests* **3**, **6**, **12**, **15**, **20**, **24**, **27**, **30**, and *Test of Interpretation* **2**

Question	
1.	c
2.	d
3.	a
4.	b
5.	d
6.	d
7.	c
8.	a
9.	b
10.	c
11.	d
12.	b
13.	a
14.	c
15.	d
16.	b
17.	a
18.	d
19.	a
20.	c

Key to *Chapter Tests* **4**, **8**, **11**, **16**, **19**, **23**, **28**, and *Test of Interpretation* **3**

Question	
1.	d
2.	a
3.	c
4.	b
5.	a
6.	b
7.	d
8.	b
9.	c
10.	a
11.	b
12.	d
13.	a
14.	c
15.	a
16.	d
17.	d
18.	a
19.	c
20.	b

For Key to *Unit Tests*, Form B, see page 233.

To score *Unit Tests* **2 - 8** (*Test of Inter-*
2 in place of a Unit 1 Test), use page 232 for
number of the Unit Test from the column at
answers against the key in that column. For
from a maximum score of 100 to obtain the

FORM A

Key to *Unit Tests* **2, 4, 7**

Question		
	1. a	21. d
	2. c	22. c
	3. b	23. a
	4. b	24. c
	5. d	25. b
	6. a	26. c
	7. b	27. b
	8. c	28. d
	9. a	29. a
	10. b	30. c
	11. d	31. b
	12. c	32. a
	13. b	33. d
	14. a	34. b
	15. c	35. c
	16. d	36. d
	17. a	37. c
	18. b	38. a
	19. d	39. d
	20. c	40. b

Key to *Unit Tests* **3, 5, 6, 8**

Question		
	1. c	21. d
	2. b	22. a
	3. a	23. d
	4. b	24. b
	5. d	25. c
	6. a	26. b
	7. c	27. a
	8. d	28. c
	9. c	29. d
	10. b	30. b
	11. a	31. d
	12. d	32. c
	13. c	33. b
	14. a	34. d
	15. b	35. a
	16. d	36. c
	17. c	37. a
	18. a	38. c
	19. a	39. b
	20. b	40. d

pretation 1 follows Chapter Tests 1 and FORM A, page 233 for FORM B. Select the the top of the page; then match the pupil's each incorrect answer subtract $2\frac{1}{2}$ points pupil's score.

FORM B

Key to *Unit Tests* **3, 5, 6, 8**

Question		
	1. c	21. b
	2. d	22. d
	3. b	23. a
	4. a	24. c
	5. d	25. d
	6. c	26. c
	7. a	27. b
	8. b	28. d
	9. c	29. a
	10. d	30. b
	11. b	31. c
	12. a	32. a
	13. c	33. d
	14. b	34. b
	15. a	35. c
	16. d	36. b
	17. b	37. c
	18. b	38. a
	19. c	39. c
	20. a	40. d

Key to *Unit Tests* **2, 4, 7**

Question		
	1. b	21. d
	2. a	22. b
	3. a	23. c
	4. c	24. a
	5. d	25. c
	6. b	26. a
	7. a	27. d
	8. c	28. b
	9. d	29. c
	10. a	30. d
	11. b	31. b
	12. c	32. d
	13. d	33. c
	14. c	34. a
	15. a	35. b
	16. d	36. c
	17. b	37. b
	18. a	38. d
	19. b	39. a
	20. c	40. d

Date Due